# The Dock & Harbour Authority





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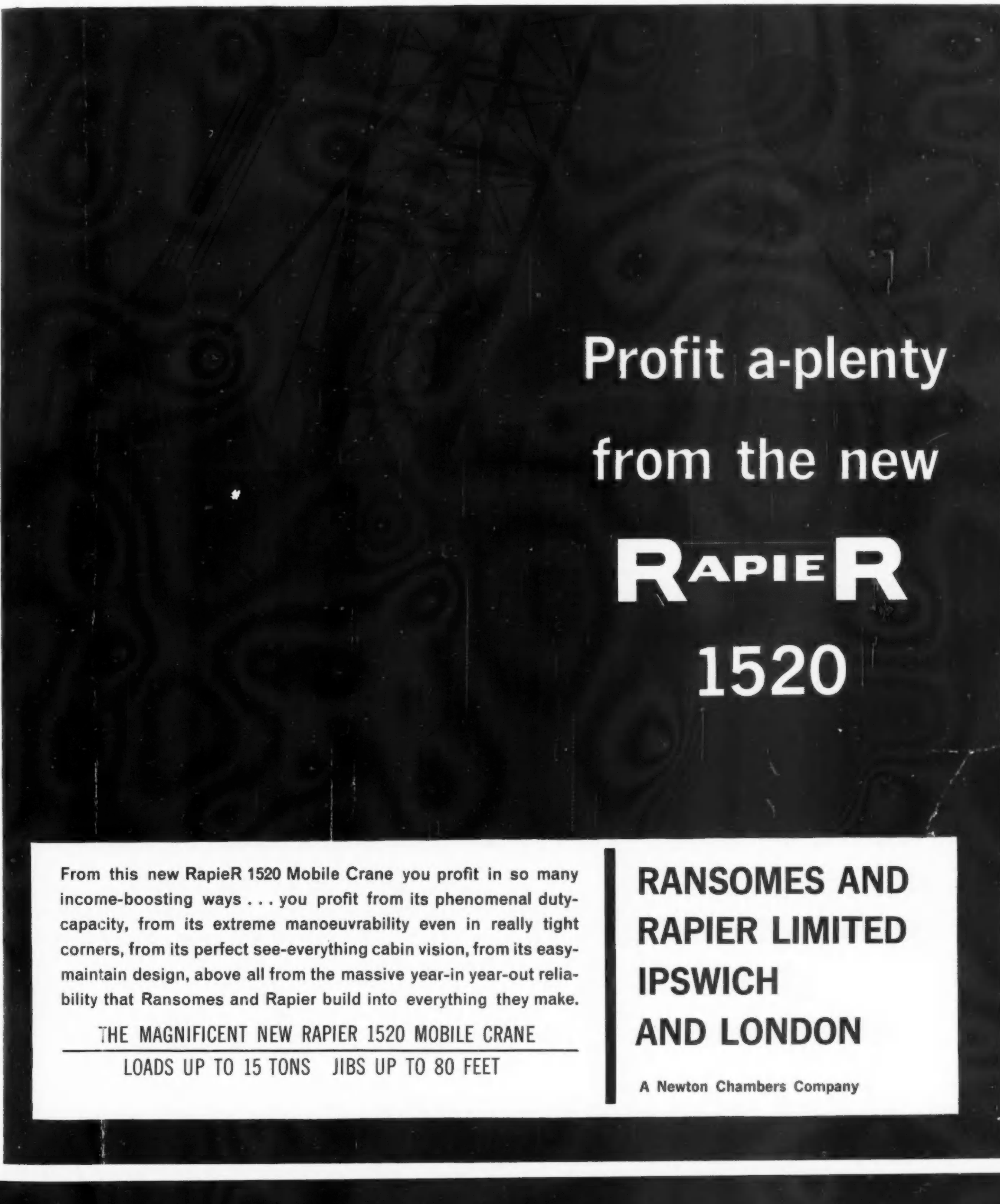

The Dock & Harbour Authority

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# Editorial Notes

### The Port of Gothenburg

The extent and diversity of the facilities provided by the Port of Gothenburg, a general description of which appears elsewhere in this issue, may come as a surprise to many of our readers. It is not possible to deduce from this account precisely how many berths are available to shipping and doubtless one of the difficulties now being faced common to all ports whose trade has been built up over centuries—is that arising from the increasing length of modern vessels. But relating the total volume of cargo passing to the aggregate length of quayage available would seem to suggest that the facilities provided are most generous, all the more so in view of their lavish equipment. Mere statistics of cargo and vessel movements do not of course supply a reliable indication of the purpose which a port is designed to fulfil.

As with many ocean ports in N.W. Europe and in the Baltic that at Gothenburg operates on the Free Port system and its development provides for a concentration of industry largely devoted to the processing and manipulating of imported raw materials and the exporting of manufactured quality products. When all this is done within a customs-free zone, money otherwise tied up in duty can be freed to finance further trade. On the other hand there is little doubt that the practice confers a strictly localised benefit and can tend to the growth of monopolies.

In seeking to overcome the restrictions on the free flow of trade which high tariffs must always produce, the operation of the free-port system does indeed provide a heightened awareness of the destructiveness of tariffs in general and of the distortions of trade which they can produce. The present world-wide movement towards the liberalisation of trade by the progressive dismantling of tariff barriers is of course directed towards a policy of facilitating imports and as such it is likely to have wider and more beneficial results than the aiding of re-exports, which has been the traditional role of the free-port system in the past.

### Some Observations on Port Problems

The two addresses given respectively by Mr. Andrew Crichton and Lord Simon, of which full extracts appear in the following pages, throw up in high relief some of the problems facing port authorities. In some respects the addresses are complementary; in others they are wide apart, because one deals with that unpredictable entity, the human being, and the other with material issues the shaping of which is within the province of those controlling them. For example, Mr. Crichton diagnoses the root of the trouble so far as labour is concerned as the continuance of the system of casual employment. He asserts that over the past 16 years an improvement in the position in the docks, in spite of strikes, official and otherwise, has been recorded and states that the National Joint Council for the Port Transport Industry is making a major effort to achieve more effective decasualisation. There is hope, therefore, even if it seems tenuous, that a better relationship between employers and dockers may in time be brought about, remembering that Mr. Frank Cousins, General Secretary of the Transport and General Workers Union, and Mr. Crichton are joint chairmen of this body.

It is here that the two addresses link up. Lord Simon holds that the authorities responsible for the development of a port should seek no more than to meet the demands of shipping and trade in respect of the facilities they offer, it being no service for a port authority to offer costly facilities that nobody wants. "A port should seek no more than to meet the demands made upon it."

But some of the facilities to be provided if ports are to meet modern demands are very costly and would include improved methods of cargo handling. This implies mechanization and extended use of labour-aiding equipment which, in turn, would require an accommodation with labour. Union leaders will need more than ever to impress on their members that time saved by ships in port when loading and discharging means in the end more work for everybody engaged in the docks. The suspicion that "speeding up the job" will lead to unemployment must be buried for ever. However plausible this argument may have been in days gone by, modern developments in costly equipment, coupled with ever-expanding trade, make it imperative that the dockers should be made to realise that these changes can be for their benefit.

As Lord Simon points out, if docks were being planned today they might well be planned differently—the same observation applying to much else we see around us—but even as they exist today they represent not only extensive capital investment, but employment for large numbers of people. He insists, therefore, that it is socially, as well as economically sound to extend, modify and improve existing ports to meet modern requirements, where that is possible, rather than to start again somewhere else.

It is intriguing to note Lord Simon's views on leased berths and facilities. He urges that the port authority, assuming that it is charged with some overall responsibility for development, must ensure that leased berths and leased facilities are sufficiently employed. He is not sure that the ordinary pressure of economics takes care of this. The value of an available berth against a contingency is not, as he says, easy to calculate, but there will probably be found to be a large measure of agreement in his statement that a port handling large quantities of general cargo ought to keep a proportion of berths available for common use—which, incidentally, would probably from time to time help out the occupiers of leased berths when their ships had "bunched" or been delayed. The matter, indeed, may be approached from a wider angle than that of shipping and dock interests. More than

ever this country depends for its very existence on its exports. These consist almost entirely of manufactured, or semi-manufactured articles which are carried largely in cargo liners. Surely a strong case can be made out for modification or adaptation of arrangements which at present often result in a number of ships waiting outside the docks for accommodation at berths within. Is there not here a need for rationalisation?

This point was raised in a letter which appeared in our last issue. The writer suggested that with a few bold strokes of imagination on the part of many authorities their ports would be able to deal with a larger volume of cargo more expeditiously and efficiently than they do now, even without undertaking any major schemes of re-building and development. He instanced wharves, licensed to deal only with particular commodities, which could be freed to handle general cargoes, and which, furthermore, would provide the spur of competition, which at present is frequently lacking. The writer also raised the controversial matter of shift working. If there are shipowners who, as he said, would gladly employ labour for a night shift, or possibly on a three-shifts per 24-hour basis, is there not here a profitable—in both senses of the word—line of inquiry? If surplus labour can be absorbed and men earn overtime instead of merely drawing their "fall back" money, why in the name of common sense, it may be asked, does not somebody do something about it? Ships would be cleared more rapidly, the export trade would be helped, and the problem of casual employment and even of unemployment might virtually disappear in the docks.

**A Field for Further Enquiry**

It is perhaps not to be expected that the articles referred to above should provide categorical answers to the important questions that they raise. Their value lies more in the fact that they have opened up a profitable field of enquiry. Lord Simon's observations in regard to rented properties are particularly apt. Regardless of the circumstances surrounding the acquisition of property the question is whether present ratepayers should be called upon to pay for future benefits. Whilst not intending to discourage the exercise of foresight in providing for future development before it is too late it may generally be accepted that only property devoted to the use under consideration should be included. Where scarce natural facilities have already been brought into productive use, however, the alienating of them to private users introduces much more controversial issues and it may possibly be held that the treatment of the subject still further obscures the subtle yet essential distinction which must be made between public and private utilities if the public interest is to be assured—a distinction which port authorities must never lose sight of.

Given that the object sought is to encourage a fuller use of the resources provided, it may be questioned whether the desired result might not better be attained by other means with less sacrifice of what many will consider an important point of principle. For the alienating of a developed site to a private user necessarily implies a dilution or a circumscribing of the public regulatory function designed to protect the interests of **all** users of the public facility without discrimination. The handing over of a deep water frontage to a private developer reduces the scope of effective control still further and should properly be resorted to only where it serves an industrial purpose and not a public one. But apart from the question of public policy involved it might be remarked that the trend in business circles today would seem to be in an opposite direction as evidenced by the growing practice of leasing plant and equipment and by the device of "lease-back," doubtless stimulated by the fact that rent payments are a legitimate business expense, deductible for tax purposes, which may often be more advantageous than the permitted write-off of capital.

There seems to be no cogent reason why the port authority should depart from the time-honoured practice of providing the common-user facility itself for it is perfectly possible for a shipowner to be given virtual ownership of a terminal during the period of his use, and adequate control of the services he requires to operate it, title to the fixed asset remaining with the port authority throughout. This can be done by the granting of a licence embodying universal conditions governing its use which, in point of fact, would not differ in a material way from those which a shipowner must needs accept if he is the actual owner of the premises in question. Such a procedure is most desirable under present operating circumstances; it will become absolutely essential if and when container working becomes more general—an increasing likelihood if only for the reason that there is now a much wider range and variety of merchandise unsuited for stowage in depth.

The difficulties of securing a proper growth of capital investment in the public section and, at the same time, a fair and adequate compensation for its commercial use, could perhaps be best overcome by financing it, not by the port authority's own stock issues, but through the medium of a statutory authority such as the Public Works Loan Board, which would enable loan funds to be redeemed by sinking fund contributions at varying rates within the duration of the redemption period. There is much also to be said for confining the scope of a port authority's direct responsibility within a seaward limit extending a short distance off its quays or dock entrances, beyond which maintenance of sea approaches would be treated as a national obligation financed by general taxation, combined as necessary with coastal protection wherever an appropriate order is made. In the interest of efficient administration, of course, the port authority might still carry out the conservancy work, but as agent for the national authority. Relieving the traffic of a port in this way from the burden of preserving what is in fact a national asset would at the same time make it easier to formulate a more general policy towards the development of ports better equipped to serve a national purpose. Whilst on the subject of finance we might observe too that the incidence of municipal rating on a port authority's immovable property is worthy of renewed study. Calculating this according to a 5-year running average of gross revenue, without separate assessment, on a base designed to produce the same present rate of contribution, might well provide an important incentive without loss to anyone.

It is becoming apparent that closer attention should be devoted to the designing of more equitable tariff structures. It is of course impossible to give effect to all the innumerable factors which enter into rate-making and a strictly logical approach may sometimes give rise to the wildest incongruities. Where public facilities are concerned, moreover, it is not sufficient to say that charges for their use should not be made for the reason that they are not required. Nevertheless, it should still be possible to devise a more equitable adjustment of rates so that they would be more closely related to the profitability of a voyage.

Finally, in the area of labour affairs, it would seem that little progress can be made in Britain so long as the state of dichotomy now permeating the industry is allowed to persist. Where the legal employer has no executive authority and the so-called "employer" may often be more correctly described as the user of a public service, almost anything can happen. That the system should display some obvious defects is not at all surprising. The astonishing thing is that it should work at all. The business of port transport in this country should be organised more after the pattern of other industrial activity and if this were done its special problems of regular employment might become more amenable to solution.

# The Port of Gothenburg

## Recent Developments and Future Plans

By ULF ENBÅGEN

GOTHENBURG is the principal port of Sweden and the second biggest city with 405,000 inhabitants. West from Gothenburg is the open sea. Railways and roads converge on the city from the north, east and south. The Trollhätte and Göta Canals link the port by water with the great lakes in central Sweden. Gothenburg also has a central position in relation to the Scandinavian capitals Copenhagen, Stockholm and Oslo. Out of six planned motor roads for the European traffic, two will be of special importance to Gothenburg viz. No. 3, Lisbon - Paris - Brussels - Hamburg - Frederikshavn - Gothenburg - Stockholm and No. 6, Rome - Berlin - Sassnitz - Gothenberg - Oslo.

The Port of Gothenburg is comparatively ice free. Even in very hard winters the port's own ice breaker can easily keep the port open to shipping. The tide is insignificant and does not present any problems. Vessels can arrive at and leave the port at any time by day or night.

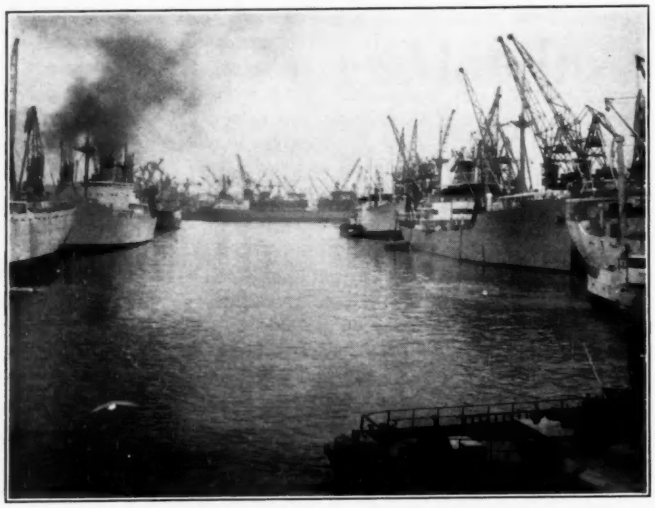
The port is owned by the city. Executive authority responsible for the administration of the harbour is vested in a board consisting of nine members, six of whom are appointed by the City Council, two by the Gothenburg Chamber of Commerce and one by the Swedish Government.

The city and the port were built at the beginning of the 17th century as a central point for Sweden's shipping connections with Western Europe. Until about 1850 there were no stone quays in Gothenburg except those along the harbour canals in the centre of the city. With the establishment of the East India Company in 1731, there began one of the great epochs in the history of the port; the big armed ships exported to the Far East Swedish copper, iron and wood and returned loaded with tea, china, cloth, mother of pearl and spices. Later, during the Napoleonic Wars at the beginning of the 19th century, Gothenburg was of great importance as a transit harbour for England, when the English trade on the Continent was blockaded.

The progress of industrialization in Sweden and of Swedish foreign commerce during the last hundred years has forced a continuous development of the Port of Gothenburg. During the last decade more than 100 million Swedish Kronor (£7 million) have been spent on new construction works and the modernization of the port. Eight new berths with 9-10 m. (29½-33-ft.) water depth have been built for large cargo vessels, several new electric quay cranes and other mechanical equipment have been installed, new transit sheds and warehouses have been erected, and old berths and sheds have been modernized. Comprehensive extensions have also been effected for the oil traffic.

The quays and piers owned by the Harbour Board cover a distance of 13 km. In addition there are 3½ km. privately owned. Transit sheds and warehouses have a total storage space of

General view of the Port of Gothenburg.

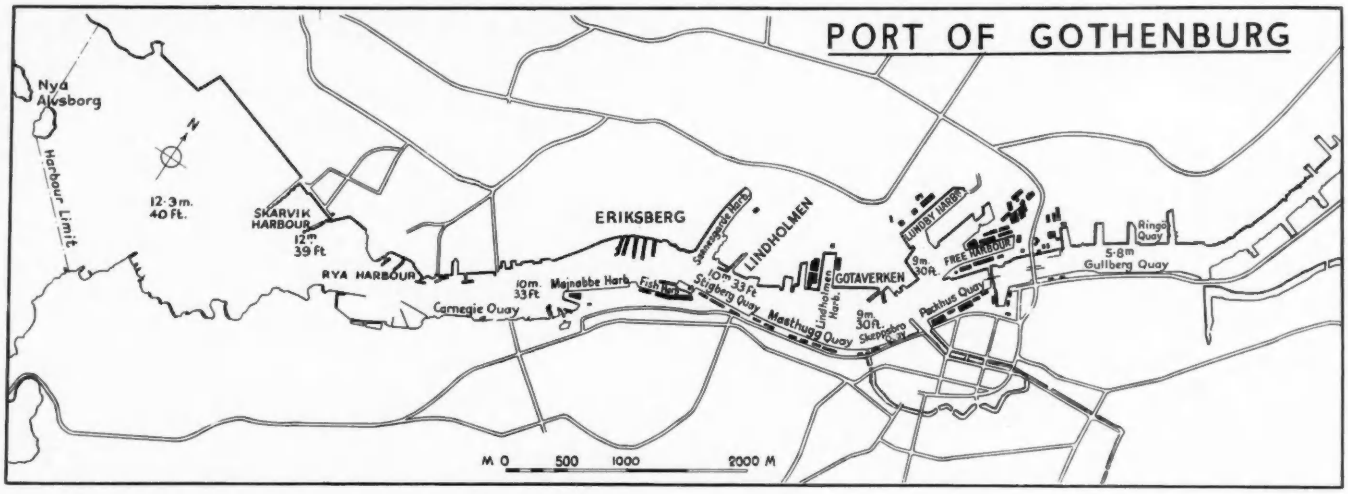


The Gothenburg Free Harbour opened in 1922.

and Majnabbe Harbours have a total of 24 berths with 9-10 m. (29½-33-ft.) water depth for the big overseas cargo liners.

Regular shipping lines to South America, the west coast of North America and to the Orient have their berths in the Free Harbour. The Lindholm Harbour is mainly used by shipping lines to the Far East and the east coast of North America. The Lundby Harbour is principally reserved for liners running between Gothenburg and ports in Africa, Australia and North America. The Stigberg Quay is used for general cargo traffic and is also the terminal for the Swedish American Line's passenger vessels to New York. The Swedish Lloyd Line's passenger vessels to London start from the Majnabbe Harbour, where on the north side, with 10 m. (33-ft.) water depth, are four berths also for cargo liners.

The Lundby Harbour, opened in 1952, is the first general cargo harbour built specially to facilitate the work by means of fork lift trucks. The apron is 48 m. (157-ft.) wide. Four railway tracks run the length of the quay and there are wide lanes for lorries and other traffic with abundant space for storing goods within the working area. The quay is 600 m. (2,000-ft.) in length and is equipped with 20 electrical cranes. The sheds are only




170,000 sq. m. (1,820,000 sq. ft.). In the Free Harbour two of the sheds are furnished with refrigerating storage for fruit and other perishable goods. There are 170 km. of railways serving the harbour and these are linked to six main-line railways.

Cargo handling is highly mechanized, and a total of 215 electric travelling cranes are in operation on the quays, the majority being of 5-ton capacity. There are also four floating cranes available—the largest has a lifting capacity of 150 tons and is self propelling; it is easily manœuvred by Voith-Schneider propellors. Forklift trucks, mobile cranes, elevators and many other mechanical facilities assist in expediting the business of the harbour. Floating cranes and mobile cranes are directed to different parts of the port by a radio telephone plant service and 45 berths in the harbour have ship to shore telephone communications.

The harbours of Gothenburg are built on both banks of the Göta River and extend from the old fortress Nya Älvsborg eastwards along the river a distance of 15 km. or nearly 10 miles. The entrance to the harbour in 1957 was deepened to 13 m. (42½-ft.) from the Vinga lighthouse to Knippelholmen and to 12.3 m. (40-ft.) from Knippelholmen to the Skarvik Oil Harbour. Further eastwards the harbour is dredged to a depth of 10 m. (33-ft.) as far as to the Stigberg Quay, then to a depth of 9 m. (29½-ft.) to the Free Harbour. Further upstream the depth is 5.8 m. (19-ft.)

The Stigberg Quay, the Free Harbour, the Lindholmen, Lundby

The Lundby Harbour opened in 1952.

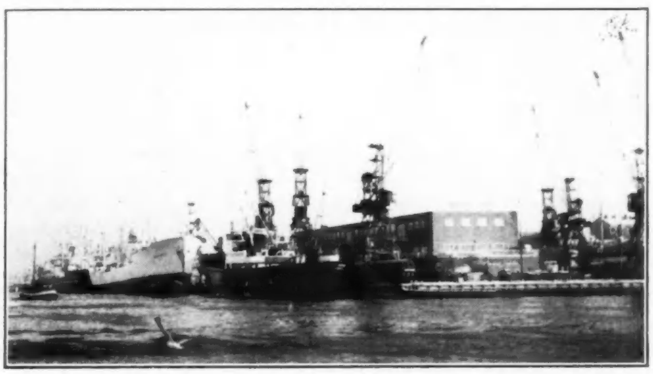
used for storage in the ground floor where goods are piled by fork-lift trucks. The Majnabbe Harbour, built in several stages between 1951-1958, is planned on similar lines.

The Stigberg Quay (opened 1910), the Free Harbour (opened 1922) and the Lindholm Harbour (opened 1939) on the other hand have narrow aprons and the sheds are often built up to four stories high with balconies, where goods can be landed directly by the quay cranes.

**Programme of Further Improvements**

An extension of the Free Harbour with two new berths (to the nine existing) and a new transit shed will be started next year. The Kville Pier, to the south of the Lundby Harbour and created when this harbour basin was dredged is planned for general cargo traffic during the next few years.

There are some 50 berths for vessels engaged in the North Sea and Mediterranean traffic. At the Masthugg Quay are berths for regular lines to English, Dutch, Belgian, French, Spanish, Portuguese and Mediterranean ports. The Packhus and Gullberg Quays are used by vessels to and from Germany, Holland, France, Denmark and Norway. Regular lines to the Baltic ports are moored in the Lindholm Harbour.



The Majnabbe Harbour showing the London Pier in the foreground.

An extensive modernization scheme is now in progress on the 60 years' old Masthugg Quay. The apron of the 11 berths is being widened by new concrete decks built further out in the river and at a later stage new transit sheds will be erected to replace the old sheds on this quay. Forklifts are used extensively here for transporting goods in units, especially the Swedish Lloyd's shipments between Gothenburg and English ports; the widened apron will facilitate the work of forklifts and other rolling stock.

The Sannegård Harbour (built 1908-1914) is mainly used for coal traffic. During the last decades the import of coal and coke to Sweden has decreased considerably. In 1939 the import to Gothenburg was 1½ million tons and it is now only about 300,000 tons a year. A reconstruction of the Sannegård Harbour is therefore in progress in order to transform part of the harbour for general cargo traffic.

**Oil Handling Facilities**

The Gothenburg Oil Harbour is the largest in Scandinavia. One third of the Swedish consumption (about 3½ million tons yearly) is imported at Gothenburg. At the Rya Oil Harbour, opened in 1930, are three piers erected by the Harbour Board and another two piers built by oil interests; the water depth is 10 m. (33-ft.). During the last 10 years the building of a new oil harbour at Skarvik has been in progress to the west of and in close proximity to the Rya Harbour. This work was completed in 1957. The length of the Skarvik Pier is 265 m. (870-ft.) and the water depth is 12 m. (39-ft.). The pier can accommodate fully laden tankers up to 50,000 tons d.w. (A description of this pier was printed in the May 1958 issue of this Journal.)

The Skarvik Harbour in 1959 was extended by the inclusion of a large area of land and now contains 800,000 sq. m. (198 acres) of storing grounds, where the big oil companies and oil consumers are now building new tank plants for the ever increasing distribution of petroleum products. The Koppartrans and Nynäs oil refineries close to the oil ports are connected by pipelines to the Skarvik Pier. A new pier is also planned at the Skarvik Harbour; this will initially have a water depth of 12 m. (39-ft.) but it is scheduled for deepening to 14 m. (46-ft.) in the near future. Preparations for a new pier at the Rya Oil Harbour also have been started. This pier will replace some of the existing piers which must be removed to make way for a new bridge which is now under construction between the south and the north bank of the river.

**Improving Traffic Communications**

The Götaälv Bridge, opened in 1939, is now, apart from the ferry services, the only existing connection between Gothenburg on the south and north side of the river. The above mentioned Älvsborg Bridge and a tunnel, the Tingstad Tunnel, one km. to the east from the Götaälv Bridge, are two big projects now started in order to relieve the urgent need for better communications within the harbour area and for the motor roads to Gothenburg. It is expected that both will be completed during 1965 or 1966. The Älvsborg Bridge is planned as a suspension bridge with a span of about 450 m. (1,480-ft.) and a vertical clearance from M.W. of 45 m. (148-ft.), which means that even the big passenger liners of the Swedish American Line will be able to pass unimpeded. The total width of the roadway will be 28.5 m. (94-ft.) providing space for six traffic lanes and two pedestrian walkways. The Tingstad Tunnel will be of about the same length as the bridge and will have three traffic lanes in each of the two roadways.

**General Statistics**

At the beginning of this century transoceanic shipping developed rapidly and many new shipping companies came into being. The port is now an important shipping centre with about 1,225,000 gross register tons belonging to Gothenburg shipowners. Today Gothenburg is linked to all ports of importance by more than 70 regular shipping lines. Three large shipbuilding yards, AB Götaverken, Eriksbergs Mek. Verkstads AB and AB Lindholmens Varv are situated within the harbour area. New buildings totalling some 350,000 gross register tons are launched each year and, in addition, their excellent facilities are also at the service of vessels visiting the port. Eight floating and graving docks owned by the shipyards are available for repairs and cleaning. The largest dock, owned by AB Götaverken, can accommodate vessels of up to 45,000 tons d.w., and the Eriksberg Yard is now constructing a new floating dock the capacity of which will be even greater.

During the last decade much has been done for the welfare of the port workers. Modern canteens and waiting rooms for crane drivers, dock workers and other harbour personnel have been erected in different sections of the port. A new up-to-date machinery workshop for the Harbour Board was built in 1959. At present an enlargement of the central Harbour Office on Norra Hamngatan 8-10 is in progress.

The tonnages of vessels visiting the Port of Gothenburg during the last 10 years have been continuously increasing. For 1960 the movement of entering and departing ships rose to a peak of 19,952,528 net register tons. The tonnage for the current year will certainly exceed 20 million tons.

*(concluded at foot of page 252)*

# Some Observations on the Problems of Port Administration

## The Need for Concerted Action

Two addresses bearing on the problems confronting the ports of the United Kingdom were recently given in London—one by the chairman of the National Port Employers' Association and the other by the chairman of the Port of London Authority.

Between them they covered the "human" and the "material" assets of the docks and suggested future lines of thought and inquiry.

Mr. A. J. M. M. Crichton set out to discuss why there is so much trouble in the docks and came to the conclusion that "something revolutionary" in the essentially conservative context of the docks is necessary to strike at the root of the "cancer". That "something", he urged, must be the removal to the greatest possible extent of the casual basis of employment and all that goes with it.

Lord Simon's approach, on the material side, was to consider what can be done to extend, modify and improve existing ports to meet modern requirements, rather than to start again somewhere else. Port authorities, he asserted, should seek no more than to meet the demands of shipping and trade. It was no service to them for a port authority to offer costly facilities that nobody wanted. It was for the users of the port to say how they want development to proceed, if for no other reason than in the end they will pay for it.

It should be added that Lord Simon emphasised that his views were personal and unofficial.

The keynote of both addresses was co-operation—between employers and dockers, and between those who run the ports and those who use them.

### Industrial Relations in the Ports*

By A. J. M. CRICHTON

**An International Problem**

Charles P. Larrowe, in his book "Shape-up and Hiring Hall", wrote "Longshoring has provided some of the most colourful chapters in American labour history. In several respects the industry is unique". If by colourful the writer meant not merely picturesque but turbulent as well, we could easily substitute for American "British or Brazilian," "French or Australian". In fact, it has been very nearly a universal experience in reasonably free societies that the docks have been focal points of industrial struggle; chiefly, no doubt, that struggle has been between employer and worker, but there have been struggles, too, between worker and worker or trade union and trade union and, occasionally, if not so openly, between employer and employer.

The "public image" of the docks' industry is not a good one. The reason for this is that a very large section of the community either have been or thought they have been (which for this purpose is the same thing) adversely affected by trouble in the docks. The exporter, for example, has seen a customer lost through late delivery. The manufacturer has had production affected by delay in the import of raw material. In both cases the consequences may re-act on the workers concerned. Coming nearer home to all of us, we have had dock strikes blamed for immediate increases in the price of perishable foodstuffs. In the result the man in the street feels that something is pretty badly wrong and makes these typical statements and asks these typical questions.

Why do dockers behave like that? After all they're better off than most workers.

Why don't the trade unions control their members? They have made agreements, they should see that their members stick to them.

What are the port employers doing to allow this to go on? The industry is their responsibility; why don't they stand up to the dockers and to the unions. Why don't they do something?

These questions all add up to the general question: "Why is there so much trouble in the docks?"

That is a fair question and it should be answered. I shall try to answer it so far as I can, but it is perhaps better if first I clear up one or two misunderstandings which lie behind the subsidiary questions.

Progress is inevitably somewhat crab-like, two steps forward and one back. That has been very much the case in the docks and all I want to say is that the devastating strike of tally clerks a year ago and the "strawboard" strike this year should not blind us to that the fact that 1956 to 1961 were less troublesome years as a whole than 1950 to 1955 which, in turn, were less difficult than 1945 to 1950. These last two strikes too, were by, or engineered by, minority groups and followed a period of two years free from any major strikes. Nor should it be forgotten that a number of important areas have had very little trouble.

The great majority of dock strikes have been unofficial, often not merely against the advice of the trade unions, but in direct defiance of union orders. This state of affairs, is not, of course, peculiar to the docks; it is a problem facing the whole trade union movement which, if it is not solved soon, will seriously imperil that movement's influence, if not existence. Perhaps on an encouraging note I should say that employer/union relations are good; we can talk frankly to our opposite numbers and have not hesitated to say what we think, as employers, about the lack of union discipline. Also, I am confident that both sides are fully seized of the real urgency of curing the dangerous disease that afflicts our ports. Indeed, if ever there was a time when it was vitally necessary for trade unions and employers to combine to give leadership in the real and mutual interests of their respective members it is today.

Example and leadership have always succeeded where exhortation has failed. The port employers will support the trade unions in any constructive action they way take and, in return, will expect the same measure of co-operation.

**Why is there so much trouble in the Docks?**

The second part of the quotation with which I started this address goes a long way towards giving the answer. Most of the causes of the special labour problems in the docks' industry lie in the industry's unique characteristics. What are these?

(a) An exceptional concentration of labour in large numbers in a comparatively small area. The ports are pressure points through which the lifeblood of trade moves and automatically they are the points where the flow can most easily be stopped.

*Abstracts from an address delivered to the Society of Shipping Executives, at the Royal Society of Arts headquarters in London, 7th November. Mr. Crichton is a managing director of the P. & O. Steam Navigation Company and Chairman of the National Association of Port Employers.

The temptation to the agitator is obvious, and not only to the agitator, but to the dockworker himself.

(b) The variety of ships and cargoes to be handled. This factor varies. There are the berths where habitually cargoes and ships of the same type are handled, usually bulk cargoes. Labour difficulties there are comparatively infrequent and comparatively simple of solution. But the far commoner thing, taking the industry as a whole, are ships of varied construction carrying a multiplicity of cargoes in all manner of shapes, sizes and packing. In short, a docker must put his hand to a variety of tasks and is always liable to come up against the unfamiliar, the unexpected, the unpleasant, or even the actively dangerous situation —fertile breeding ground for trouble.

(c) The urgency attending all dock work. The need for speed, for higher outputs, runs through every industry, but this need applies in the docks in rather a special way. So far as an even speed flow of goods can be arranged on the analogy of a production line, that is the ideal that can rarely be achieved.

With the best will in the world, just too many different spheres of activity require to be co-ordinated. So we tend to have in the docks the need for spasmodic speed, interspersed with delays, all overlaid with the demands of the individual interest; the ship-owner for his ship, the importer for his goods, the road haulage contractor for his lorry.

So again, if in a narrower field, the temptation to opportunism confronts the dockworker.

**The Casual Nature of the Work**

Twice I have referred to opportunism on the part of the dockworker, but to use the phrase of Lord Shaw, of Dunfermline, writing his report forty years ago, after the first, the biggest and probably the most significant inquiry into the affairs of docks' industry in this country or any other, "it would be a mistake on a very large scale" to lay all the blame upon the dockworker. As Charles P. Larrowe, who I have already quoted earlier, went on to say, "No other industry has offered a more extreme form of casual employment".

The casual form of employment breeds the casual and opportunist attitude of mind. It has done more than any other factor to encourage the dockworker's tendency to seek to exploit situations favourable to him.

This diagnosis of casual employment as the main problem of the industry, does not dawn on us today as a blinding flash of light. In fact, in the 19th century, sociologists were calling for an end to the system. The remedy they saw was simple enough, that there should be a closer equation between the number of men seeking dock work in a port and the amount of work normally to be done.

Second, that given a controlled labour force, men who could not be given work should still receive a minimum payment of "maintenance" as it was called.

It took until sometime between the wars in this country to reach the first stage—control of the size of the labour force. It was not until after the outbreak of the second world war that the second object was achieved.

Now, in most of the major ports of the world, not only is the size of the labour force restricted, but there is a system of payment for men who are not offered work. Arrangements for engagement of men vary from hiring calls, controlled to a large extent by the unions (on the West Coast of the U.S.A.) through more or less jointly controlled (U.K. and Germany) and Government controlled (Australia), dock labour schemes, to cases where the responsibility rests with the employer (Rotterdam).

It is often asked: Why not employer control in this country? It is my purpose to deal primarily with things as they are and with things as we would have them in the context of the circumstances in which we must plan and act. If someone says "change the circumstances", I can only point out that three times proposals for employer control of the dock labour force have been advanced by the National Association of Port Employers to independent inquirers, without success. In each case, the decision was taken against the background that very serious strikes had occurred co-incidental with the system of joint control and with every argument advanced that could reasonably be marshalled against joint control.

In short, we recognise, as port employers, that there is joint control with unions and employers equally represented on the Dock Labour Boards, which regulate recruitment into, discharge from and the discipline of the dock labour force. I should perhaps emphasise, in case of misapprehension, that these Boards have nothing to do with actual operations in the docks, the loading and discharge of ships or the industrial agreements relating thereto.

In fact, whatever the relative merits of various systems of control, the underlying problem is the casual form of employment. Indeed, were it not for this much of the "controlling" would become unnecessary. The weakness of our arrangements is that, although they have provided a basic security, have given greater regularity of employment and have mitigated the economic effects of the casual system, they have not brought about real regularity of either employment or earnings.

Our first approach to this problem in recent years, was to look at the effects of this system upon the status of the dockworker, upon his sense of "belonging" to the industry. We reached agreement with the unions on the establishment of a pension scheme on top of the national scheme, upon medical examination of all new recruits and upon the introduction of pilot training schemes in London and Liverpool. These measures in themselves have been successful and will, I am sure, contribute substantially in the long run to the efficiency and well being of the industry. Yet the core of the problem remains and can be summarised as follows.

(a) The basis of engagement and employment for the majority of the men is still casual. The dock labour scheme benefits and high average earnings do not prevent wide fluctuations in the individual's earnings from week to week, and wide fluctuations in earnings between individuals. From this has followed (b) the casual attitude towards the observance of agreements and conciliation procedures, as exemplified by the industry's experience of strikes. (c) The casual attitude militating against the efficient use of manpower, as shown by resistance to modern methods including mechanisation and adherence to restrictive practices.

There comes a time in all experience when radical problems must be dealt with by radical measures, if they are not to be allowed to sap progressively the strength of the body.

As a result of the disastrous tally clerks' strike of October, 1960, and the subsequent London strike in the spring of this year, both sides of the port transport industry, employers and unions, determined that it was inescapable that something should be done, and done quickly, to strike at the root of the cancer in the Docks. Accordingly, The National Joint Council for the Port Transport Industry decided that a major effort must be made to achieve more effective decasualisation if the reputation of our ports was not to be prejudiced further.

What we aim at is something revolutionary in the essentially conservative context of the docks.

Our object is to remove to the greatest extent possible and consistent with the varying conditions at the different ports, the casual basis of employment and all that goes with it. We hope and believe that when men realise better what is the security of their employment and the regularity of their earnings, they will be less inclined to follow out every harum scarum who strikes, without first using the agreed machinery of conciliation; that they will see the fatuity of restrictive practices that can

only retard their wages, and will appreciate the value of mechanical aids which can only lighten their load and speed their earning power.

To implement our aims we set up a working party of both sides of the industry in June. That working party's recommendations were issued to all local joint committees last October and those local port committees have been asked to report back what can be done by the 1st January, 1962.

Much progress has been made but, of course, there are obvious problems and more will emerge. Above all, there is the problem inherent in the fluctuation of the volume of cargo and, let it be admitted, even without the accentuation of that problem by the actions of governments throughout the world, a considerable fluctuation would remain. This factor alone may well affect the measure of decasualisation to be achieved in some ports.

But so great is the relevance of the casual form of employment to the special intensity of problems of labour relations, that we must not neglect any opportunity for solution, even if the answer cannot be applied everywhere at the same time and in the same way. When all is said and done, what remains fundamental is that there should be a real willingness on both sides to move from entrenched positions and relinquish established practices. Decasualisation in a port may depend, for example, on the willingness of the men on the one side to accept mobility between jobs, and by the employers on the other accepting that in time of under-employment they have less freedom of selection than at present.

## Seaports as Links in the Transport Chain*

By VISCOUNT SIMON

### Variety in Ports and Traffic

The thoughts I am going to offer to you are the outcome of a good many years spent in the shipping industry, and some few years, more recently, in port administration. They do not represent an official view, and they carry no authority whatever.

Ports vary enormously, both in the way in which they are organised and in the type of traffic they handle. We have at one extreme ports constructed to handle a single cargo for a single owner, developed as a direct adjunct to the business they serve. At the other end of the scale is the large port handling many different types of cargo, inwards and outwards, for a large number of merchants and manufacturers. I shall be speaking mainly about ports that handle a wide variety of traffic, but much of what I have to say applies equally to the specialised ports.

Looking round the world, it will be found that the location of ports has often been decided a long time ago by considerations which do not necessarily apply with equal force to-day. If we had to start again, we might well plan things differently—and that is no doubt true of much else that we see around us to-day. At the same time, once a port has been established for many years, a whole complex of trading and other ancillary activities will be found to have grown up round it. These are sometimes, with rather an unfair sneer, called "vested interests". But they represent not only extensive capital investments but employment opportunities for large numbers of people, and it is socially, as well as economically, sound to extend, modify and improve, existing ports to meet modern requirements, where that is possible, rather than to start again somewhere else.

The growing size of ships engaged in international trade, which has been so marked in recent years, has created special difficulties. Some ports cannot physically be adapted to deal with larger ships, and their importance must gradually decline. But in many cases—and this applies particularly to river ports—the difficulty has been met by the development of a subsidiary port nearer to the sea than the safe haven (safe from pirates as well as from storms) which was originally chosen. Familiar examples of this are the development of Bremerhaven, as an adjunct to Bremen, or of Le Havre, which was, historically, a subsidiary port for Rouen. The development of the Tilbury Docks is another case in point nearer home.

A modern port must, then, be capable of receiving these larger ships. But that does not mean that every port is required to receive a "Queen Elizabeth" or a 100,000-ton tanker. Just as the shipowner, unless he is merely seeking prestige, will build the smallest ship that will do the job he has in hand, so the authorities responsible for the development of a port should seek no more than to meet the demands of shipping and trade in respect of the facilities they offer. This will perhaps sound a rather unenterprising outlook, unless a port has a subsidy from outside sources—and I am thinking mainly of ports in this country which have to stand on their own feet—all capital expenditure has to be paid for ultimately by the users. It is no service to them for a port authority to offer costly facilities that nobody wants.

### Basic Requirements

The two first obvious essentials are to have adequate access to and from the open sea, and adequate access to and from the land areas the port is required to serve. So far as access from the sea is concerned, differing conditions apply at ports where there is a large tidal range and at those where there is no tide or only a small rise and fall. If a port is required to deal with ships of any given draft, the depth which has to be maintained in the approach channel, especially across bars and other obstructions, will be less when the tidal range is great, provided it is practicable to require ships to make these crossings at high water, and provided adequate depth of water is available inside the port to accommodate the ships when they arrive.

It may at first sight appear from this that a port with a large tidal range has some advantage. But it is only in this particular respect. The condition that there should be adequate depth of water to berth ships will usually in tidal waters necessitate the construction of docks with locked entrances, involving very heavy expenditure far outweighing any saving that may be possible in the cost of maintaining the entrance channel. Moreover, the need to lock ships in and out imposes further tidal restrictions on the movement of shipping, and although in certain cases it is possible to berth ships alongside wharves or jetties in tidal water, the conditions of work are always more difficult than where only a small rise and fall of tide has to be contended with. All in all, the ports in this country with a large tidal range stand at a considerable and insurmountable disadvantage in comparison with our near Continental neighbours.

The maintenance of the sea approaches to a port, which may be a very costly affair, is in most cases the responsibility of the port itself, which means that it has to be paid for by the trade of the port. It is, however, worth noting that in certain instances—for example, at Rotterdam and at Hamburg—the cost of maintaining the port approaches is very largely borne by the State authorities, and falls, therefore, on the general taxpayer. I do not propose to argue whether that is right or wrong. I merely point it out.

When we come to consider land access, the position is completely different. In the case of the ports developed by the railway companies, access to and from the hinterland by rail has been planned as part of the project and integrated with the port development. But in most cases both rail and road access has been provided by the appropriate administrations without any direct co-ordination with the port authority. This does not pre-

*Abstracts from an address delivered to the Institute of Transport in London on 13th November. Viscount Simon is the Chairman of the Port of London Authority.

vent complaints about traffic congestion being frequently laid at the port authority's door! Recognising that internal communications have many tasks to perform besides dealing with port traffic, there is room for better co-ordination between the various authorities and administrations concerned, and this might bring substantial rewards.

It has been a general experience over the last thirty years that more traffic has been reaching ports by road and less by rail, and the same has applied to inward traffic distributed from the ports. This has necessitated much re-arrangement of facilities within the ports, but it equally calls for the re-development of lines of access outside.

And what of the facilities to be provided within the port? What the ship requires is a safe berth where she can lie—usually "always afloat", but sometimes, where conditions permit, lying on the mud at low tide. Although berths alongside a quay or jetty are usually demanded, at many ports substantial quantities of cargo are dealt with at moorings, and where ships have efficient cargo handling gear, this can be a fast and economical method of working, avoiding the heavy capital expenditure of constructing deep water quays. Obviously, however, this is only really appropriate where the cargo, or at least the greater part of it, originates from or is consigned to waterside premises, as otherwise additional handling is involved which is to be avoided where possible.

Where alongside berths are provided, these may be in docks or at open berths. I have already referred to the need for dock berths in tidal waters, and the unavoidable expense which this incurs. When the first enclosed docks were built in London, the primary aim was not to remove ships from the tideway as such, but to remove them from the depredations of pilferers, who at that time were very active in the river. The enclosed dock was, therefore, originally introduced as a means of protection for the cargo, although, as ships have developed in size since then, docks have become a necessity from an operational point of view.

**Getting Cargo In and Out**

Having got the ship into a safe berth, and assuming that adequate access to and from the surrounding land area has been provided, what more is required? The object of the exercise is not to berth the ship, but to get her cargo out and in as expeditiously and cheaply as possible without damage. The method to be employed depends on the nature of the cargo. Bulk liquids have to be pumped through pipe lines; bulk grain discharged by suction elevators or other similar machines; ores may be discharged by massive grabs or loaded by the use of moving belts. These and other specialised facilities are usually provided at separate berths, an arrangement which is not only generally convenient when full cargoes are being handled, but also sometimes necessary, as in the case of petroleum. But where part cargoes, for example, of grain, have to be discharged, it is advantageous to have mobile equipment, if this is practicable.

To determine the best method of handling these bulk cargoes, in the light of the circumstances prevailing at a particular port, obviously requires consultation and co-operation with the shippers or importers concerned. That is how facilities of this kind have always been developed. But in the handling of the bewildering variety of general cargo, those responsible—by any means always the port authority—have a very different kind of problem. The basic method of putting general cargo into a ship or taking it out has varied very little for centuries, but it is surprising to find how differently this method is applied in different ports. Thus in London, in the enclosed docks alone, there are nearly 550 quay cranes provided, in addition to a very large number on riverside wharves. In New York, as in Sydney, there are practically no cranes at all. And since at these latter places the port authority do not, in any case, provide the quayside facilities, which are the responsibility of the shipowners or the agency firms which handle ships, a port operator in this country may sometimes wonder whether the shipowners really want the cranes, which are certainly not cheap pieces of equipment.

But whether general cargo is loaded and discharged by quay cranes or by ships' gear, there remain the problems of reception and delivery. For these mixed cargoes it is essential to have transit sheds, both for the assembly of cargo prior to loading, and for sorting after discharge, and the design and lay-out of sheds, to which a great deal of thought and technical skill has been applied in recent years, has an important bearing on the efficient working of a port. In addition, facilities will need to be provided for the direct handling of cargo to and from the quay, and in appropriate cases for reception and delivery from and to barges.

Any port that is to meet the needs of its users must have, in addition to safe and adequate berths, such specialised plant for bulk handling as is required for the particular trades it deals with, and transit sheds for general cargo. Whether or not quay cranes are required in addition appears to be a matter decided on rather arbitrary grounds, or at least on grounds which seem difficult to explain. Who is to provide these facilities?

The practice varies considerably. In some ports the administrative authority does little more than maintain the water area and construct deep water quays. These and the land behind them are then leased to private undertakings who erect the sheds, provide the mechanical plant they want, and indeed perform all other functions. At other ports the shed and plant are provided by the port authority, and are then leased to users. At others, the authority not only provides shed, etc., but operates them. These different methods of working have grown up over the years, no doubt influenced by local conditions and local requirements, and he would be a bold man who sought to argue that in all circumstances one system was better than another.

**Users the Best Judges**

My personal leaning is towards getting the users of the facilities to provide them, wherever they have sufficient traffic, of their own or available to them, to keep these facilities reasonably fully employed. My reason is not so much that the users are presumably the best judges of what they want—although I think that has some relevance. I see it largely as a question of finance. So long as ports are run, as I think they should be, as non-profit making concerns which have to raise finance for capital expenditure by the issue of fixed interest bonds, it seems to me desirable, wherever it is reasonable and practicable to do so, to get the users of the port themselves to put capital into the venture. Only in this way can we get invested in the port risk capital which is prepared to wait some years for development to mature. This is broadly the basis on which Europort is being developed by the Port of Rotterdam.

The case for redevelopment along these lines is more obvious when we are thinking of large bulk handling installations, and many of these, wherever situated, have, in fact, been developed in this way. Certainly that would be true of nearly all bulk oil terminals. Similar arguments could be applied also to general cargo berths—and at many ports this is what happens. If a shipowner, or group of shipowners, or an agent with extensive connections, has enough traffic to keep one or more berths fully employed, there is something to be said for his taking a lease of suitable berths and contiguous areas—it would, of course, have to be a long lease—constructing his own sheds and providing his own cranes (if he wants them) and other equipment.

If such an arrangement is to work to the best interests of the port as a whole (which means, of course, the interests of all users

of the port), the port authority, assuming it to be charged with some overall responsibility for development, must ensure that leased berths and leased facilities are sufficiently employed. It may be thought that the ordinary pressure of economics would take care of this, but I am not sure that this is so. The value of an available berth against a contingency is not easy to calculate, but may seem larger in the eyes of the manager than the cash income receivable from a sub-letting. In any event, a port handling large quantities of general cargo ought to keep a proportion of berths available for common use—which, incidentally, will probably from time to time help out the occupiers of leased berths when their ships have bunched or been delayed.

Two developments will undoubtedly have their effect on ports—the roll-on roll-off ship and what is, horribly, called "containerisation". Neither of these developments seems likely to require the installation of much in the way of plant by port authorities, but they both bring with them problems in connection with lay-out. Both require large marshalling areas, especially container ships of the kind now used in United States domestic trade, and if these demands grow rapidly, as they may well do if and when we find ourselves in a common market with our European neighbours, special problems will face ports situated in congested areas.

**"Famine and Feast"**

One other matter I would like to refer to is in connection with cargo handling through transit sheds. We all know that trade will not flow in that nice steady way that the planner inside each one of us would like to see it do. But could something more not be done to iron out minor irregularities, as well as to forecast broader fluctuations? A review recently made of the handling of export traffic in the London docks showed clearly that during most of the period of ships' loading, the facilities were either being under-employed or over-strained. This "famine and feast" will clearly affect not merely the port and the ship itself, but the road transport organisation, and, for all I know, the manufacturer's packing and loading plant. I find it hard to believe that intelligent co-operation between the interests concerned cannot do better than this. In the exceptionally busy period after the war regulating schemes were introduced, and worked well. Was it merely a revolt against regimentation that led to their being abandoned? And, if so, was it sensible? There may be times, of course, when they are unnecessary, and during these times let them by all means be suspended. But we might do some good if the interests concerned got together again and examined this question with unbiassed minds.

Assuming that the port authority, whatever precise operating functions it performs, has an overall responsibility for the broad lines along which the port develops, how should this responsibility be exercised?

It is sometimes suggested that it is the duty of port authorities, as well as of other transport undertakings, to keep ahead of demand, to provide facilities to handle the maximum traffic that is to be expected, plus a bit more. I do not believe this is right. Whatever facilities are provided have to be paid for by the users of the port, for there are no ordinary shareholders whose dividend can be foregone. In fact, the position of port authorities is quite different from that of any ordinary business concern. If in a private business you make a mistake, you or your shareholders pay. If a port authority makes a mistake, the customers pay. It is right, therefore, that port authorities should progress cautiously.

A port should seek no more than to meet the demands made upon it. How much are the users of ports prepared to pay for unused, unwanted facilities? I would think very little, which is why it is not the business of port authorities to anticipate the requirements of their customers.

But they must satisfy them when they arise. How is this to be done? First of all by keeping in the closest possible touch both with shipowners and with shippers and importers. In many cases contact is maintained with the governing bodies of our ports. In other cases contact is maintained with a representative committee. But the actual working of this is not as easy as it may sound. The views of the various interests are not always the same, and however conscientiously representatives try to speak for their constituents, they may find it difficult to put forward a balanced view.

I know from experience how valuable this kind of association can be. But it has its limitations, and quite apart from any direct representation, not only the recognised organisations of shipowners and shippers, but every individual user of the port should be ready to discuss his plans with the authorities of the port he intends to use. It is quite foolish, and not at all fair, to present to the port authority a sudden new demand, necessitated at it may be by some new development in trade, and to expect that, like the rabbit out of the hat, satisfaction can immediately be produced.

With their practical knowledge of port working which the users cannot share in the same degree, and with the expert technical advice on which they can call, port authorities must be better placed than any of the users, individually or collectively, to make forward plans. But it seems to me vital that the users should take the port authorities completely into their confidence so that these plans can be laid with all likely developments in view—and in good time, too.

It is on that note that I would like to close. The users of the port are the people to say how they want development to proceed, if for no other reason than because in the end they will pay for it. Port authorities will, of course, and must continue to translate broadly assessed requirements into practical projects. But they, like every other transport undertaking, have only one duty, to meet the needs of trade. May we then hope that the closest co-operation will be fostered between those who have the responsibility of running our ports and those who hope to go on using them.

## *The Port of Gothenburg*

*(continued from page 247)*

The volume of imports in 1960 amounted to just over 5 million tons, a figure only exceeded in 1956. Exports, at 1,670,000 tons, were slightly higher than in 1959.

The extensive industrial district in Central Sweden, especially to the north, but also to the south of the great lakes, is the most important in the country. Gothenburg is a natural export harbour for all kinds of wooden products and the high quality iron and steel manufactured products of these districts.

Industries dependent on imported raw materials and quality industry adjusted for export have been developed successfully in recent years. The metal industry is the most important, the three big shipyards making Gothenburg one of the biggest shipbuilding centres in the world. S.K.F., Volvo, ESAB and Original-Odhner are other famous Gothenburg industries. Industries for textiles, foodstuffs and chemical products are also important.

With its modern quays and cargo handling facilities the port is well equipped to serve all classes of business. The Port Authority is, nevertheless, continuously working on new projects of extension and modernization which will enable the port to meet further developments in trade. One such project is a new large harbour, the Skandia Harbour, planned to be built westward from the oil harbours at the mouth of the Göta River on the north bank. One million Swedish Kronor have already been spent on preparatory work. The area of land for disposal is over 1 million sq. m. (270 acres). More than 5 km. of quays are planned to be built, mainly for general cargo. It is estimated that this harbour will be completed during the 1980's.

# Some Aspects of Densimetric Exchange Flow

## Including Results of Recent Laboratory Experiments

By D. I. H. BARR, B.Sc., Ph.D., A.M.I.C.E., M.ASCE.

### Introduction

An exchange flow will occur after the opening of a gate or other such division which has separated bodies of still water of the same surface level but which differ slightly in density. The less dense water flows over the more dense and this movement is visible at the surface. An equal flow of the more dense water must pass the location of the gate, moving under and in the opposite direction to the surface flow and this is not directly visible in full-scale circumstances. At intervals during the past thirty years idealised studies of exchange flow have been described, usually with the intention of thence deducing knowledge of practical cases;[1-4] a recent article in the "Dock and Harbour Authority" included such a comparison[5]. The present article is mainly concerned with laboratory observations of exchange flows: relatively small scale experiments can undoubtedly help to explain phenomena encountered in actual water courses, despite the fact that our present knowledge of exchange flows, even in simplified conditions, is far from complete.

### Summary of the Present State of Knowledge

The exchange flow case most commonly considered has been that occurring in a level bottomed rectangular channel, the initially separated liquids differing only slightly in density and being miscible. Salinity or temperature differences in water which result in suitable density differences are easily produced in the laboratory. In order to reduce gate opening disturbances to the least possible, a very thin barrier which lifts vertically may be fitted in grooves in a flume. The starting condition is shown in Fig. 1 (a), and Fig. 1 (b) typifies the illustrations which have normally been given of the early development of the flows; the frontal velocities of the overflow and underflow being shown as uniform and equal.

It is true that the uniformity of frontal velocity in the early stages of large laboratory experiments is quite marked. If the two bodies of water are themselves well mixed, and the movement upward of the barrier is swift and smooth, the exchange action appears to begin instantaneously. A plot of distance travelled against time for either overflow or underflow starts as a straight line through the origin. The rates of progress of overflow and underflow fronts are not, however, equal. Recent observations have indicated that the overflow moves about 12% faster than the underflow[6]. Fig. 1 (c) shows this and also gives a closer impression of the appearance of the developing flows.

In order to make non-dimensional comparison between gravitationally occasioned flows, recourse to some form of Froude number is necessary. The standard form of the Froude number (F) is $V/\sqrt{(gL)}$ where V and L are characteristic velocity and a characteristic linear dimension respectively and g is the gravitational coefficient. The derivation is given in most hydraulics textbooks. For normal comparative purposes, where water flows below air in, say, both a prototype and a normal type of hydraulic model, the gravitational coefficient could be neglected, but for internal gravitational flows, such as lock exchange flows, the effective gravitational force is reduced to $g\left(\frac{\triangle\rho}{(\rho_1+\rho_2)/2}\right)$ where $\rho_1$ and $\rho_2$ are the fluid densities differing by $\triangle\rho$. As $\triangle\rho$ is small this may be approximated by $g.\triangle\rho/\rho$, where $\rho$ is the mean density.

Thus the densimetric Froude number is $F_\Delta = V/\sqrt{\left(\frac{\triangle\rho}{\rho}.g.L\right)}$ where again the term g could be neglected for comparative purposes. Keulegan has proposed (Note 1) that $V_\Delta = \sqrt{\left(\frac{\triangle\rho}{\rho}.g.H\right)}$ should be called the densimetric velocity, where H is the total depth as shown in Fig. 1. If a velocity differing from the densimetric velocity is observed and is related to the densimetric velocity by a coefficient, K, the similarity, or otherwise, of such coefficients as between the differing tests of a series would show the applicability of the densimetric Froude number criterion to

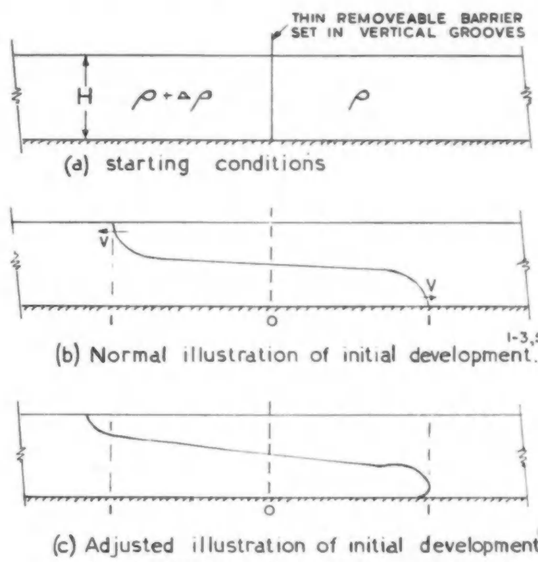



Fig. 1. Initial stages of exchange flow in an open rectangular channel.

the particular phenomena in a convenient way. Keulegan showed that the initial velocities, $V_0$, of lock interchange flow could be so compared. As exchange flows develop, viscous or eddy viscous resistance must have an effect on the velocity and he further suggested that a densimetric Reynolds number be formed using the densimetric velocity:

$$R_\Delta = V_\Delta . H/\nu$$

where $\nu$ is the mean kinematic viscosity. This is a further parameter for the comparison of both initial and extended flows.

Fig. 2 shows the variation of $V_0/V_\Delta$ (the coefficient of proportionality K) against $K.R._\Delta$ for both overflow and underflow in the free surface rectangular channel case. The continuous part of the underflow line has been fairly well established by Keulegan

(Note 1) and the writer[6] for various combinations of a range of density difference ratios ($\triangle\rho/\rho$) from about 0·0001 to about 0·1 and depths varying from 0·1 to 1·5-ft. The extended dashed portion of the underflow line is based on the hypothesis that when fully turbulent conditions are reached there will be no further scale effect. Some slight evidence of this has been obtained. In the case of the overflow line the solid portion was given by the writer[6] and subsequent experiments have tended to confirm its general location. Again the dashed part is at present hypothetical. While the lower ranges of $K.R_\triangle$ shown in Fig. 2 cover all but the smallest model or basic study occurrences, the proved upper ranges are far from characterising full-scale occurrences—which might range up to $K.R_\triangle$ values of $10^7$ in quite ordinary water course circumstances; say, a lock gate in a 40-ft. deep channel with $\triangle\rho/\rho$ as 0·027 (fresh water and sea water). There is little doubt however that the dissimilarity in overflow and underflow front velocity described above, would be found in a full-size rectangular channel. If such knowledge can be deduced from small scale studies, it is natural to consider whether further details of full-scale flows might be elucidated. Velocities at points away from the fronts, the rate of diminution of velocity of the fronts and of other velocities, and details of dilution and the mixing action at once come to mind.

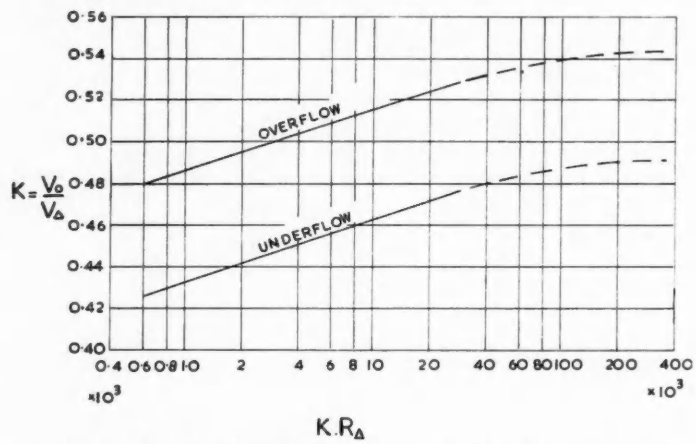



Fig. 2. Variation of coefficient of proportionality, K, against densimetric Reynolds number times K.

Observations of such aspects of exchange flows in laboratory conditions are obviously feasible, in fact many have been made but the number of circumstances possible, in particular the variety of configurations, greatly complicates correlation of the available information and can make comparison with full-scale occurrences misleading. It is appropriate to here list and discuss some of the variations; no attempt is made at exhaustiveness.

**Variations in density difference:** if water, or some other liquid, is initially at one side of the barrier and air at the other, the ratio $\frac{\triangle\rho}{(\rho_1+\rho_2)/2}$ approximates to two. Saint Venant provided the basis for an analysis of such a "dam burst" around 1880, and Keulegan, in the well-known reference book "Engineering Hydraulics" edited by Rouse[7], has summarised comparisons of this analysis with laboratory experiments. These experiments are not, however, of recent date. The dam burst problem has long aroused interest among mathematicians and recent theoretical work has suggested that the Saint Venant approach must be modified. There does not seem to have been any recent practical studies and, as will be further explained, the dam burst is not directly comparable with normal lock exchange flows.

At the other extreme even the slightest density difference can cause exchange flow. For instance the writer has found that with a $\triangle\rho/\rho$ ratio as small as $1{\cdot}8\times10^{-6}$, a typical exchange flow could be set up in a flume. In this case the water depth was 0·8-ft. and great care was taken to ensure that the bodies of water were initially quite still.

In full-size water courses the most common density difference agency is, of course, salinity; $\triangle\rho/\rho$ as between sea water and fresh water being about 0·027. For normal naturally occurring temperature differences the density difference ratio is much smaller, and this also applies to normal industrial temperature rises such as are found near power station condensing water outfalls. A great range of density variation in water due to suspended solids is possible; clear water may interact with anything from faintly discoloured water to a slurry.

**Variations in surface conditions:** free surface exchange flows have been dealt with so far. However similar exchange flows could as well occur in an enclosed flume, and later in this article such experiments will be described. The "dam burst" cannot be directly compared with a normal free surface exchange flow as though only the density difference had been changed and Bata seems to have erred in this respect.[4] Rather it should be likened to the circumstance that the less dense water might occur on both sides of the barrier overlying the more dense on the one side, as shown in Fig. 3. The surface level of the less dense water would be the same on either side of the barrier. If this level were sufficiently above the top level of the heavier water, something like equivalence with the water-air "dam burst" would result. Thus Allen and Price's comparison with a suspended silt surge appears valid.[5]

**Variations in channel configuration:** The channel may be of a uniform shape on either side of the barrier as in the rectangular flume experiments already mentioned. Apart, perhaps, from the case of an extremely narrow channel the ratio of breadth to depth does not affect the initial velocities, but the degree of side effect does alter the rate of dimunition of velocities, its influence being noted up to a breadth to depth ratio of about six. However if a triangular channel, or a trapezoidal channel with a narrow bottom were considered, it seems reasonable to suppose that the initial velocities would be modified. The same would apply to a semi-circular channel.

Interest on the development of the flows in such a uniform channel may well be concentrated on the occurrences before either front has reached an end barrier. It is difficult to arrange for sufficiently long flumes in the laboratory, and given a certain length of flume it has normally been decided to compromise by positioning the barrier near one end, usually with the more dense liquid in the shorter length.[1, 2, 6] Fig. 4 shows this case diagrammatically. Once the overflow front is checked the overflowing water tends to be retarded by its re-depression and the continuity of the process of decrease of potential energy of the system is interrupted. The reflection may be regarded as an intermediate stage between a front and a wave, less liable to suffer diminution of velocity than a front. If then in the case shown, the underflow front velocity suffers early diminution for any reason, the reflection rapidly overtakes the underflow front and causes a further marked diminution in its velocity since its depth is decreased over and above that decrease which would have occurred in a long channel without the occurrence of an overflow reflection.

If the channel shape is changed at, or near, the barrier position, a number of possibilities exist, for the present it is sufficient to mention the idealised sea and channel. Here a rectangular channel runs at right angles into the middle of one side of a large tank. The channel and tank have the same bottom level and the barrier is placed at the point of junction. This configuration also

approximates to some examples of lock practice.

Two detailed series of experimental results of exchange flows have been given in unpublished reports of the U.S. Bureau of Standards by G. H. Keulegan (Note 1). These two reports form by far the largest body of practical information on exchange flows as observed in idealised conditions so far available and it is unfortunate that they have not yet been published; both reports are, however, mainly concerned with restricted cases. The first is that of a relatively narrow rectangular channel in which the barrier is placed close to one end and the more dense water is initially in the short length so formed—the case already shown in Fig. 4. Some aspects of the flows have already been described. In addition Keulegan showed that if experiments were conducted in different sized flumes but maintaining geometrical similarity as regards to depth to width ratio and depth to shorter flume length

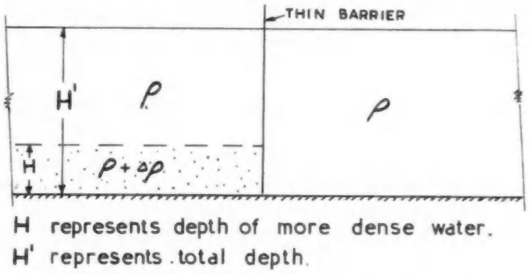
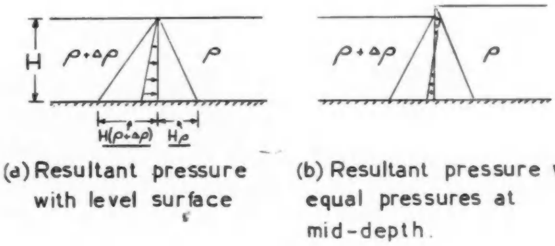



Fig. 3 (above). Starting conditions for exchange flow corresponding to the "Dam-Burst."

Fig. 4 (right). Diagrammatic illustration of reflection which occurs when barrier is near one end of channel.

Fig. 5 (below). Momentary pressures at interface after removal of barrier.



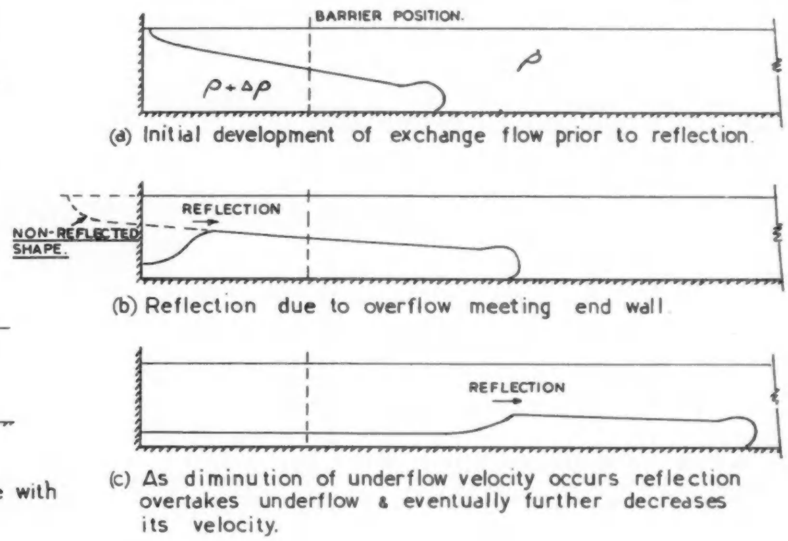

ratio, then similarity as regards the pattern of diminution of velocity of the underflow front could be obtained by keeping the densimetric Reyonlds number constant. This requires the density difference to increase in proportion to the square of the decrease in size, and involves departure from ordinary Froude number similarity. This basis for the scaling of models is therefore invalid should normal currents as well as density currents be involved.

The second case examined was that of the channel and sea, where the width of channel was again relatively small in comparison to the depth i.e. not greater than equal to the depth. The more dense water was initially in the sea. Keulegan showed that the coefficient of proportionality of the underflow is considerably greater than in the uniform channel case—around 0·57 in experiments of the same order of magnitude as those used to obtain the data for Fig. 2. Also the underflow at the entry occupied an increasing proportion of the depth instead of the more or less consant half which occurs in the uniform channel until the passage of the reflection, if any.

Since there is no reflection in the channel and sea configuration, the diminution of underflow velocity occurs much more slowly than in the uniform channel case shown in Fig. 4. Unfortunately there is no direct relation between such diminution in the narrow channel of the channel and sea configuration and the narrow channel of a uniform channel configuration even where both compartments are long. Still further from direct comparison is what appears to be the standard case of exchange flow, the broad uniform channel where both compartments are very long. The writer has suggested that knowledge of this, the standard, case could be used to determine the extent to which hydraulic models can be utilised in problems involving both internal and normal gravitational flows.[6] Such are normally operated under the Froude criterion as regards the normal flows and this restricts the density ratio as between model and prototype to one in order to satisfy also the densimetric Froude criterion.

In both the cases studied by Keulegan, observations of dilution were made; these show that dilution is an important feature of diminution of velocity of a front, but it is fair to say that this feature of exchange flow is still largely unexplored.

This brief review of the present state of knowledge of exchange flows indicates the need and scope for further study, much of which requires very large apparatus. However progress can also




be made in comparatively small apparatus as described in the following section.

**Enclosed Flume Experiments**

Since O'Brien and Cherno[1] first studied densimetric exchange flow there has been dubiety as to whether during such flow the free surface remains level or not. As this has bearing on the further understanding of the phenomena, it was thought worth while to examine the circumstances in further detail.

First consider the level surface hypothesis. Upon removal of the barrier the forces on the momentarily vertical interface are not equal, the resultant unbalanced force being towards the less dense liquid at all depths as shown in Fig. 5 (a). An explanation of the start of exchange flow may be stated as follows. For reasons of continuity it is necessary that the opposing flows should be equal. Also a logical transference pattern must occur with the minimum absorption of energy due to acceleration and the overcoming of viscous friction (normal or eddy). The maximum rate of reduction of potential energy commensurate with these conditions is obtained from the flow pattern commonly observed despite the necessity for the overflow to overcome the varying pressure difference appropriate to the depth. O'Brien and Cherno, working with fair depths for the laboratory and with saline water of the order of density of sea water opposed to fresh water, stated

that surface elevation differences had not been observed, and this also applies to subsequent experiments.

In the discussion of O'Brien and Cherno's paper, Grunsky raised the question of actual lock opening practice, where it is normal to first ensure that the total water pressure on either side of the gate are equal. This is attained when the local pressures at mid-height are equal and in the case of fresh and sea water the superelevation of the fresh water would be about 1·3 per cent. Grunsky writes "Sudden removal of the partition, of course, would cause an over-run of fresh water in one direction, while there is an underflow of salt water in the other direction, although somewhat checked in its velocity of flow by the superelevation of the fresh water . . . . ." This may be interpreted as proposing that the internal and the normal gravitational flows might be considered separately and that an approximation to actuality would be obtained by the superimposition of these flows as they might occur separately. Grunsky, then, took the view that the level difference of actual lock practice constituted a modification to the basic situation. The momentarily resultant forces at the start of the equal total pressures case are shown in Fig. 5 (b).

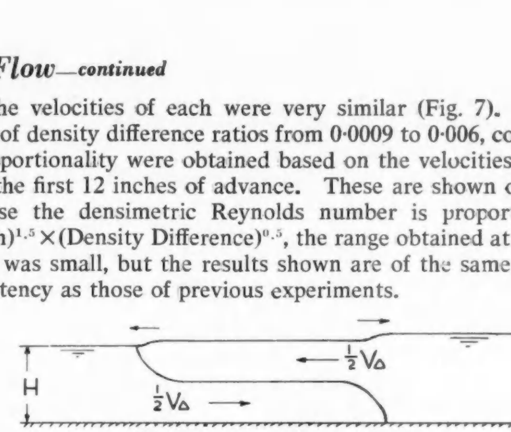
In the same discussion (on O'Brien and Cherno's paper), Howland introduced a hypothesis, fairly recently developed by Schijf and Schonfeld,[3] that variation in surface elevation should coincide with the tips of the advancing overflow and underflow. Schijf and Schonfeld examined the phenomena of lock interchange flow from a theoretical standpoint, and made the assumption that the basic case was that with equal pressures at mid-depth, as shown in Fig. 5 (b). Considering their diagram (Fig. 6) it will be seen that the formation of an intermediate level, centred at the gate, provided a means of balancing the difference in level assumed as the starting position without any overall movement of the two bodies of liquid, a solution perhaps more elegant than that originally suggested by Howland.

Had the developed flow under a free surface actually been symmetrical it would have been relatively easy to completely disprove the surface elevation hypothesis merely by carrying out the experiment in a totally enclosed flume. However, as mentioned earlier, the initial velocity of the overflow has been consistently shown to exceed that of the underflow by about 12%, the variation apparently being caused by the differing modes of flow necessary for the penetration of the tips of the respective fronts as between having a frictional boundary and a virtually non-frictional boundary.

Considering now the case of totally enclosed exchange flow, it seemed reasonable to expect that symmetrical development of underflow and overflow would take place with the coefficients of proportionality both corresponding to those previously obtained for the underflow.

An enclosed flume, in practice a 4·15 inches square pipe 8-ft. long, was pivoted so as to move through 90° from the vertical to the horizontal position. One side was transparent and was placed so as to be vertical when the flume was lying in the horizontal position. The end of the flume which was uppermost when in the vertical position was made removeable for filling.

While in the vertical position the flume was partly filled with saline solution, then using an arrangement similar to that described by Debler,[8] fresh water was run in so as to complete the filling of the flume but leave a clear cut separation between it and the saline water below. Either the saline or the fresh water was coloured. When the flume was rotated into the horizontal position, the end having been secured, a symmetrical exchange flow developed. As the rotation was not instantaneous, distortion of the fronts occurred for the first six inches or so of movement, but thereafter the appearance of both the overflow and the underflow was like that associated with an underflow in an open flume, and the velocities of each were very similar (Fig. 7). Using a range of density difference ratios from 0·0009 to 0·006, coefficients of proportionality were obtained based on the velocities attained after the first 12 inches of advance. These are shown on Fig. 8. Because the densimetric Reynolds number is proportional to $(\text{Depth})^{1.5} \times (\text{Density Difference})^{0.5}$, the range obtained at constant depth was small, but the results shown are of the same order of consistency as those of previous experiments.




Developed exchange flow

Fig. 6. Illustration of exchange flow after Schijf and Schonfeld.[3]

This seems to indicate that the question of surface elevation is largely irrelevant, no differences having been possible in the enclosed flume and no departure from the expected having taken place. It seems that the dissimilar bodies of water in an open flume act together so far as surface waves are concerned, and are not to be likened to, say, two immiscible liquids where the interfacial surface tension could be appreciable.

When an actual lock gate is opened, much more mixing, relatively, must result than from the vertical withdrawal of a thin barrier in a flume. In order to study the effect of such mixing the enclosed flume was filled with water of three different densities, 1·002, 1·001 and 1·000 gm/ml, in that order from the bottom with the middle layer coloured. From the previous experiments values could be ascribed to $V_0'$ and $V_0''$ the initial velocities appropriate to density difference ratio of 0.001 and 0.002 respectively in the particular flume. On bringing the flume to the horizontal two exchange flows at first developed as shown in Fig. 9 (a). The velocity of the underflow of the middle density water into

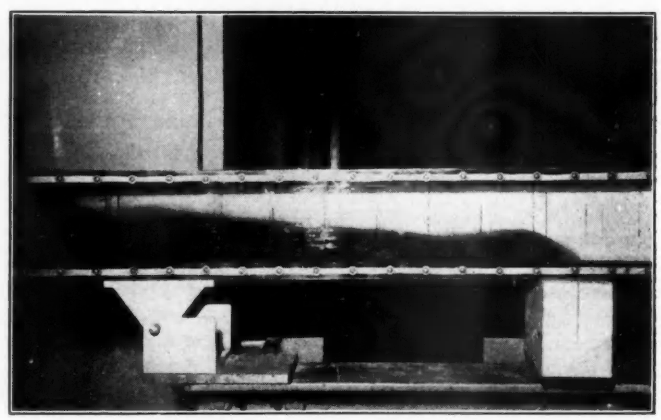


Fig. 7. Symmetry of exchange flow in an enclosed flume.
**Note**—Allowance must be made for the fact that traces of the more dense (coloured) water show when mixed into the overflow, while corresponding traces of the less dense (clear) water do not show in the underflow front.

the least dense water was observed (Underflow B in the figure). 8 the intermediate water underflow velocity was close to $V_0''$ As explained previously, initial distortion occurs, but within an extension to depth ratio of about 2, a velocity close to $V_0'$ was noted. Once the condition shown in Fig. 9 (b) is reached, the exchange flows are no longer independent. The underflow of the most dense water passed into the follow up of the underflow of the intermediate water, and a similar condition arose with the overflows. Starting from a 1-ft. long intermediate zone placed

at 2-ft. 9-in. to 3-ft. 9-in. from the initially low end of the flume, it was found that at an extension to depth ratio of the order of although the underflow tip contained by then only traces of the original intermediate zone water. Of course due to the unsymmetrical position of the intermediate water at the start, reflection at the other end of the flume had occurred by this time, but this hazard of short flumes can never be held to increase velocities over those which would have obtained in a longer flume. It can thus be justifiiably assumed that the reflection from the overflow had not in this case affected the underflow velocity before it in turn had reached the end of the flume and thus brought the experiment to an end.

At the low densimetric Reynolds numbers obtained in the shallow flume, comparatively little mixing occurs during exchange

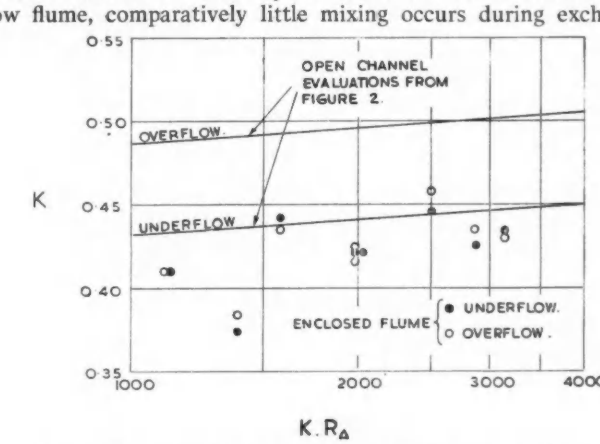
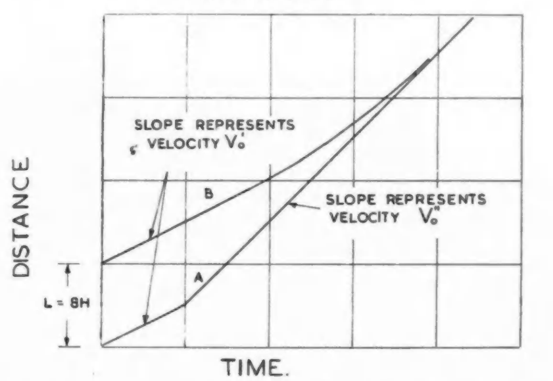



Fig. 8 (above). Coefficients of proportionality from enclosed flume.

Fig. 9 (right). Diagrammatic illustrations of double exchange flows in enclosed flume.

Fig. 10 (below). Diagrammatic plot of distance travelled against time for underflows of double exchange flows in enclosed flume.




flow. It was found that the flume could be slowly tilted back to the upright position without much further mixing and the coloured intermediate water, though now somewhat diffused, returned to more or less its original position.

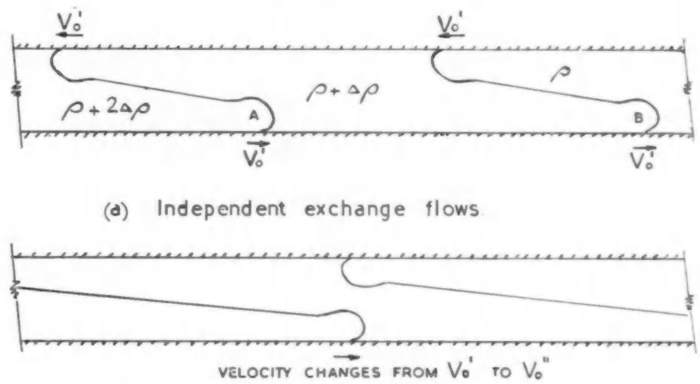
On returning the flume to the horizontal, exchange flows developed again, more slowly at first than when starting from clear interfaces, but with the underflow tending to reach the same final velocity $V_0''$ before the end of the flume was reached. Another repetition of the cycle, the zone of diluted intermediate water being further lengthened at the start, further slowed the development of the exchange flow but not the final velocity.

In further experiments with the same density differences, the intermediate layer was made much longer, from 2-ft. to 6-ft. from the bottom of the 8-ft. long upright flume. On rotating to the horizontal and initiating the exchange flows, the underflow of the most dense water into the intermediate water was observed. (Underflow A in Fig. 9 (a).) Allowing for the initial distortion due to the method of starting the exchange flows, the underflow had a velocity of $V_0'$ until the condition shown in Fig. 9 (b) was reached, then there was a fairly sudden rise in velocity to a value of $V_0''$. In explanation of this consider that the velocity continued at $V_0'$ After the confluence of the flows there would be a sharp drop in the rate of increase of kinetic energy but no change in the rate of decrease of potential energy. This would not be stable and in fact the increase of velocity of the second underflow, and presumably of the second overflow, occurs.

On returning the flume slowly to the vertical and then starting again, the same delay in the onset of the flows, but not in the final velocities, was noted.

Fig. 10 shows a deduced diagrammatic plot of distance against time for both underflows in the case just described. It would be observed in a long flume starting from clear cut interfaces and with vertical barriers L' apart where L' is 8 times the depth.

The foregoing tests suggest that the mixing caused by the opening on an actual lock gate will delay the onset of exchange flow, but will have little effect on the final velocities and extension patterns. Thus the results from small scale basic studies or from




(a) Independent exchange flows

(b) Development of interference between exchange flows

a model study without the complete simulation of the full scale lock gates, will not be invalidated by the mixing caused by the full scale lock gates, but some allowance must be made, in comparing model with prototype, for the delay in the full scale flows due to the lesser clear cut initial conditions.

**In Conclusion**

An attempt has been made to review our present knowledge of exchange flows and to show that there are still large gaps in our understanding of such flows. Much more experimental work is needed, especially in very large apparatus. There is, however, a sound basis for proceeding empirically from small scale observations to full size occurrences, and indeed this is at present the only approach since little progress has yet been made on the analysis of exchange flows on a hydrodynamic basis. Despite the need for very large apparatus, progress can still be made with small pieces of apparatus as shown by the simple experiments described herein.

**Acknowledgments**

The experiments described were performed by F. Smillie, A.R.C.S.T., in the Civil Engineering Laboratory of the Royal College of Science and Technology, Glasgow, under the supervision of the writer who is most grateful to Mr. Smillie for his diligence and also to Professor Wm. Frazer, B.Sc., Ph.D., A.R.C.S.T., A.M.I.C.E., A.M.I.Mech.E., for his permission to make use of the results.

(*for references see foot of next page*)

# Rehabilitating Steel and Timber Marine Structures

## A Method of Repairing Damage and Deterioration

*(Specially Contributed)*

The deterioration of steel and timber piling and of other maritime structures is a world-wide problem. In particular, the ravages of *Limnoria* and *Teredo* on timber piles and wharves, and the corrosion of steel piles, especially in the splash zone, are responsible for the expenditure of millions of pounds each year.

Dock near Miami, Florida, showing creosoted wooden piles before and after being restored with Speed-Crete.

Research to find the means of preventing, and into methods of repairing, the damage caused by these attacks has been the concern of many scientists and engineers for decades and although some progress has been made, no complete solutions have yet been found.

During recent years the problem has been receiving increasing attention in the U.S.A. and it is estimated, to quote only one instance, that damage to timber piling in U.S. Naval installations is costing over $50,000,000 a year. In U.S. waters, the *Limnoria* causes the greatest damage. They can work in creosoted piling and it has been proved that they can live swimming in creosote.*

Following studies of all the preventive methods at present in use, it is apparent that a physical barrier comprising some form of jacketing is required. The application of such a barrier is also effective against the living organisms in the pile at the time of treatment, since to sustain life the borer is dependent on contact with sea water.

The grouting of piles to form a jacket is well known practice but, hitherto, the difficulty has been to find a material which can be applied under water without separation and without the use of forms. For some years past, this problem has been the subject of investigation by scientists at the laboratories of the International Speed-Crete Research Corporation, Fort Lauderdale, Florida who, after extensive study and experiment, have now developed an additive called Speed-Crete which, when added to Portland cement and sand, produces a quick-setting grout that can be applied to timber or concrete piles, either pneumatically or by hand. On the pneumatic application, restoration below the water line is done by hand-packing.

Steel sheet piling at Miami before and after repairing with Speed-Crete.

It is claimed that Speed-Crete can be made to stay in place without forms of any kind, even in the face of heavy wave action. Unlike ordinary cement, it will bond with iron, steel and other metals, forming a firm protective coating against moisture and

*Reference: Dr. Harry Hockman, Director of Chemistry Division USNCEL, "Corrosion," January 1959.

## *Densimetric Exchange Flow*—continued

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other elements and therefore acting as an anti-corrosion agent wherever corrosion is a problem. It also is dimensionally stable when used, so that no shrinking or check cracks occur during setting. It is pliable in water but not soluble and reaches its initial set point in four minutes. It attains an average strength of over 2,250 p.s.i. in 48 hours and over 4,500 p.s.i. in 28 days. Once the materials are properly mixed, the grout absorbs no more water while being applied, no matter what the depth or pressure may be.

Dolphin piling being restored at a pier at the City of St. Petersburg.

The new product has already been used extensively in America. At Long Beach (N.J.) the badly deteriorated concrete piles of the 1,000-ft. long fishing pier were recently repaired with a considerable saving in time and cost.

The material also has been used to rebuild the timber piles supporting a building and a bridge in the Miami area. On both these structures, the supporting creosoted piles had been badly damaged by *Limnoria* and *Teredo* borers and their original strength had been reduced by 50 to 80 per cent. Later, testing engineers inspected the bridge; 43 piles had been completely restored and 45 repaired with no disruption of traffic. The repair included steel reinforcing rods embedded in Speed-Crete. The engineers removed the material over an area of one square foot and found no corrosion, rust or other deterioration and the steel was still covered with blue mill scale.

Another interesting application was the patching of a large sunken barge. The holes were covered with expanded metal and then the Speed-Crete was applied under water by a diver. The leaks were sealed in only 7 hours and, when pumped dry, the barge was towed 150 miles to New Orleans without the use of pumps as the repairs effectively prevented any leakage.

It is claimed that the value of the new additive is threefold: its speed of working reduces labour costs and wasteful expenditure of time; its simple yet thorough application dispenses with expensive equipment and replacements; it is stronger than ordinary cement. Port and consulting engineers have expressed approval of the material on the basis of the two or three years it has been in service but, at this stage, they are not prepared to predict its long-range effectiveness.

# Containing Oil Spills with a Pneumatic Barrier

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(Coastal Engineering Laboratory, Technical University of Denmark)

**Oil Spills and Fires in Harbours**

The need to handle ever increasing quantities of oil presents many problems in harbour development and design, not the least of these problems being concerned with the risk of oil spillage and subsequent fire within the harbour area. Whereas on the open sea such spillages may be regarded only as a nuisance, albeit a considerable one, within the confined space of most harbours an oil spillage and fire, or "spill-fire," presents dangers of the first magnitude. This is due to the possibility of the spreading of the fire, with the spilling oil, over the water surface, so that a fire on one tanker may spread to another and may even engulf a whole line of vessels lying together. Already sufficient examples of tanker fires exist to indicate the possibility of such a "chain-reaction" spreading from one vessel to another[1] while the catastropic consequences of a conflagration of these proportions have recently been very clearly expressed.[2]

Investigations carried out in one major port[1] suggest that a spill-fire could be initiated either directly, as a tanker berth, or indirectly, as a result of collision in the fairway. In both of these cases the oil would not only spread under gravity, but might also be carried with the tidal streams into the vicinity of adjacent tankers and other craft. These investigations then lead to two lines of study, the one related to the tidal conditions within the harbour concerned; the other related to the spreading of oil over water under the influence of gravity.

The first of these studies may be followed by standard hydrographical procedures. The second, however, presents more difficult problems, which have only been partly solved by recent theoretical and experimental work.[3] However, it is now possible to calculate the behaviour of oil spreading over water in certain practical cases, and these provide the time available before oil discharged from one vessel arrives at another.

The problem of determining the behaviour of one fluid spreading over another naturally leads to the problem of preventing this spreading altogether.

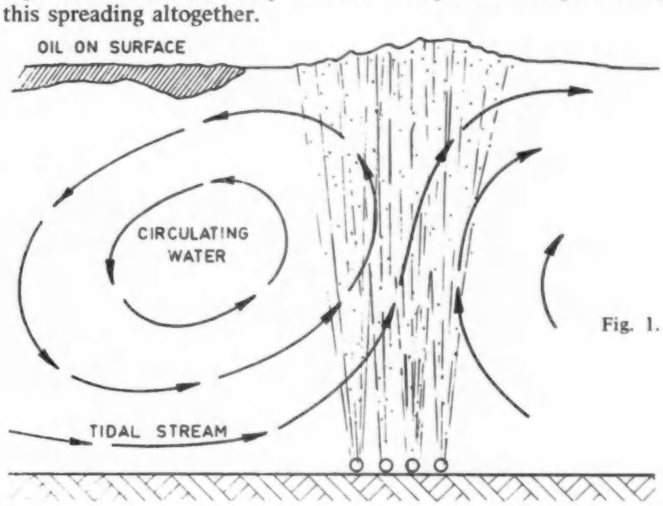


Fig. 1.

It will be clear that the oil is only spreading relative to the surface water, so that if this surface water can be given a velocity equal and opposite to that of the oil then the oil will be effectively stopped. It is then necessary only to induce such a velocity in the surface layers of the water, and it is for this purpose that a "pneumatic barrier" can be employed.

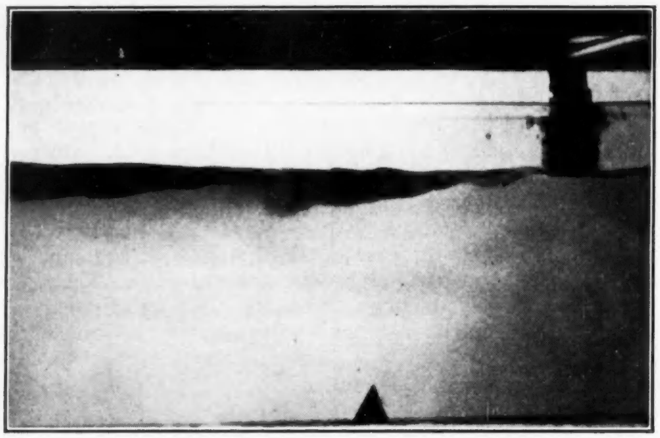

Fig. 2.

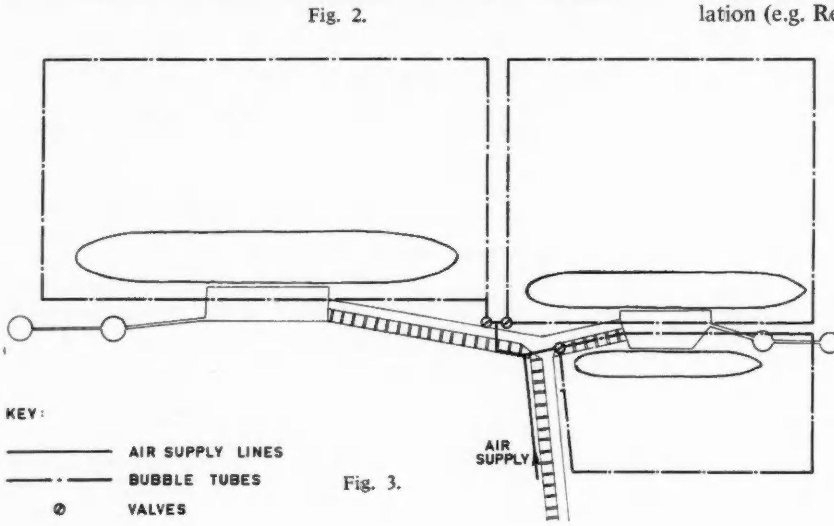


Fig. 3.

Fig. 4.

**The Pneumatic Barrier**

For the present purposes the pneumatic barrier may be formed from a tube, or ensemble of tubes, lying on or just above the sea bed. Air can be discharged through these tubes and, via very small holes, into the water. The resulting ascending streams of bubbles then carry up the entrained water, this water spreading out at the surface to form a surface current, the water thus displaced being replaced by water drawn in along the sea bed. In quite a short time a circulation is built up in the water, and in the final state the only purpose of the bubbles is to maintain this circulation (Fig. 1). In this way, then, a surface current is produced and oil may be held on the surface, even in the presence of a tidal current. Fig. 2 is a laboratory photograph of just such an oil layer held on the surface by a counter current.[3]

Many quantities are involved in the design of a pneumatic barrier. Thus the number, spacing and diameter of both the tubes and the holes in the tubes have to be determined and related to the overpressure of the air supply. From this data the air demands and resulting compressor capacities have to be calculated. However, as a result of an extensive series of studies carried out at the Technical University of Denmark in connection with this and other applications of pneumatic barriers or "bubble screens," it is now possible to calculate the behaviour of these devices with some accuracy. It is also possible to determine the combinations of parameters leading to the most efficient installation (e.g. Ref. 4).

**Application of the Pneumatic Barrier in Practice**

For the purpose of isolating spill-fires, two types of pneumatic barrier installation are envisaged. The first of these is a permanent installation, either placed around individual tanker berths or used to seal off one part of a harbour from the other parts. A typical installation is illustrated in Fig. 3. In this installation the air tubes, control valves and compressor sets form a complete system, capable of sealing off any one berth from all the others in about 20—30 seconds. The system requires only a relatively small outlay, is easy to maintain and, of course, it does not interfere in any way with ship manœuvres. It is, moreover, little affected by the sort of waves experienced in a harbour.

For a spill-fire initiated in the harbour fairway a mobile installation is envisaged, this then forming a part of the normal fire-fighting equipment of the appropriate harbour craft. The operation of a model installation is shown in Fig. 4, where the manner in which the spreading oil is contained by the bubble screen may be clearly seen.

In conclusion it may be said that, although several practical problems remain to be solved, more especially as regards the mobile installation, the pneumatic barrier does appear to represent a practical solution to the oil spillage problem. It appears to have several advantages compared with most types of floating installation and to represent a potentially valuable addition to the devices available for localising and fighting oil fires in harbours.

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# Cathodic Protection For Marine Installations

By H. E. MORGAN, M.A., AM.I.E.E.

Iron and steel structures and equipment in docks and harbours suffer considerable corrosion. They are generally exposed to damp, salt laden air, and frequently the atmosphere is further polluted by neighbouring industries. Condensation, spray and erosion, increase the rate of attack in some areas while other zones suffer because they cannot receive any maintenance. This last class includes the buried and immersed piles, piers, dolphins, etc., that often form the foundation of the harbour system. These are, however, susceptible to protection by properly engineered cathodic protection.

**Corrosion**

The earliest records of sea water corrosion belong to antiquity, and there are reports of the corrosion of ship's equipment and structures in ancient literature. More recently, though still some 300 years ago, Charles II and Samuel Pepys reported accelerated corrosion of iron rudder bolts on the English fleet and correctly ascribed this to the lead sheathing on the hull.

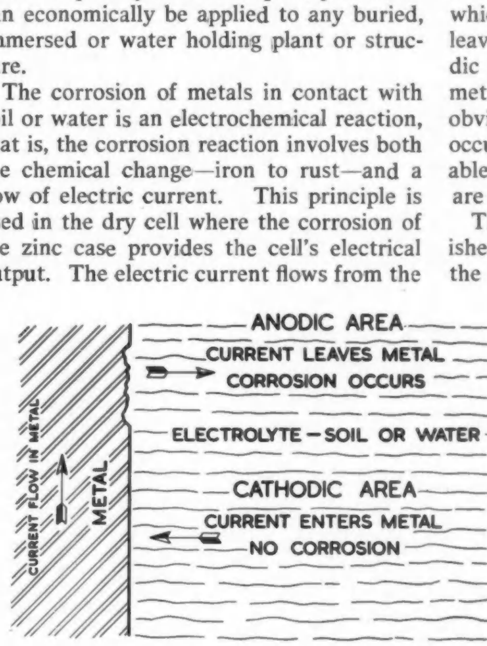
A scientific approach to the study of corrosion began in the late 18th and early 19th century, and the relationship between the electrical and the chemical phenomenon was investigated in considerable detail. Davy first suggested that a metal could be protected by the process which we now know as cathodic protection, and in 1837 the British Association commissioned Robert Mallet to investigate the corrosion of wrought and cast iron in sea and estuary water. His recommendations included cathodic protection, but like so many other scientific advances this was ahead of its time, and the only available material was sacrificial anodes made of zinc. But for a brief attempt by Edison using electric-magnetically generated current there was little or no use of cathodic protection until the early 1930's. A great impetus to the subject came with the use of long steel pipelines for oil and fuel transmission in the United States, and at the end of that decade several companies were operating comprehensive cathodic protection schemes using both zinc anodes and impressed current derived through copper oxide rectifiers from a.c. power and fed into the ground through scrap iron anodes.

The success achieved with the early protection led to its wide and almost indiscriminate use. The surplus magnesium at the end of the war meant that sacrificial anodes were used and by far the largest number of installations at the present are engineered by this technique. Advances in conventional electrical generation and in anode materials have taken place in the last few years, and there is now a wide variety of techniques by which complete protection can economically be applied to any buried, immersed or water holding plant or structure.

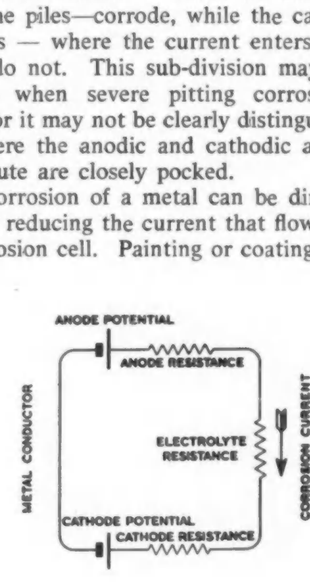
The corrosion of metals in contact with soil or water is an electrochemical reaction, that is, the corrosion reaction involves both the chemical change—iron to rust—and a flow of electric current. This principle is used in the dry cell where the corrosion of the zinc case provides the cell's electrical output. The electric current flows from the metal into the soil or water (technically called the electrolyte) at the anode and from the soil or water into the metal at the cathode. These are respectively the zinc case and central carbon rod in a dry cell. The flow of electricity from the metal into the electrolyte at the anode is accompanied by the corrosion of the metal there; while at the cathode the flow of electricity from the electrolyte—be it soil or water—into the metal prevents its corrosion. In a dry cell the anode and cathode are of different materials and are not joined electrically; when they are connected, an electric current flows and the battery anode corrodes.

A typical structure, say a jetty pile, in contact with mud or water will suffer corrosion by a similar mechanism. Various areas of the metal surface will become anodes and cathodes depending upon variations in the metal, its surface treatment and the electrolyte. The electrical potential differences beween these area will not be great—probably less than 100mV, or only a few per cent of the dry cell potential—but all the anodes and cathodes will be short-circuited together through the bulk of the structure. The areas of the metal which act as anodes — where the current leaves the piles—corrode, while the cathodic areas — where the current enters the metal—do not. This sub-division may be obvious, when severe pitting corrosio n occurs, or it may not be clearly distinguishable where the anodic and cathodic areas are minute are closely pocked.

The corrosion of a metal can be diminished by reducing the current that flows in the corrosion cell. Painting or coating the structure increases the electrical resistance of the anodes and cathodes and a perfect coating will successfully reduce the corrosion; but, if the coating has flaws or holes in it then the current is concentrated at these and deep pitting results at the anodes. The corrosion current can also be reduced by lowering the electrical potential difference between the anodes and the cathodes either by controlling the purity of the electrolyte or by adding inhibitors to it.




Corrosion mechanism with associated electrical currents.



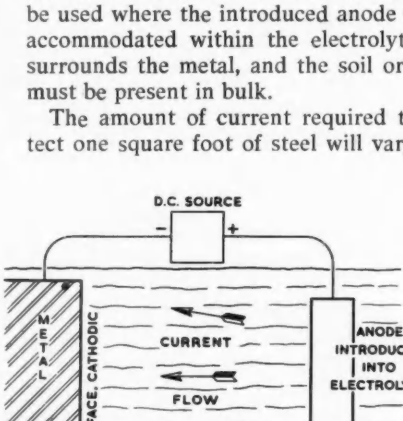

Equivalent electrical circuit.

**Cathodic Protection**

As only the anodes corrode, it should be possible to prevent the corrosion of the structure by flowing current on to it from an introduced external anode so as to cause the whole of the structure to be a cathode. This is the principle of cathodic protection.

The structure is permanently maintained in this condition by the current and receives complete protection from a properly engineered installation. The method can only be used where the introduced anode can be accommodated within the electrolyte that surrounds the metal, and the soil or water must be present in bulk.

The amount of current required to protect one square foot of steel will vary with



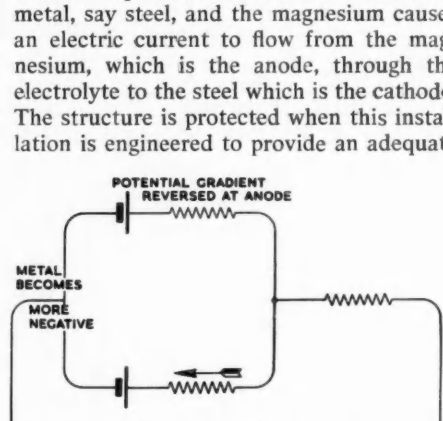

Cathodic protection.

several factors. Bare steel in sea water may require 5 mA per square foot while uncoated steel in the soil can be protected at current densities of 1·5 mA per square foot. If the steel is coated with a coal tar enamel the current required may be only a few microamps per square foot. Other metals, lead, copper and aluminium may similarly be protected at comparable current densities.

To achieve cathodic protection the current must flow from the electrolyte on to the metal, and so the metal must have a more negative potential than it had when corroding. The adequacy of the cathodic protection can be determined by measuring the potential of the metal relative to some constant reference device. The reference potential is usually obtained from a piece of metal immersed in a known solution of one of its salts. The solution is connected through a porous plug to the corroding electrolyte and this device is termed a reference electrode or half cell. To use it, a conventional voltmeter of high resistance is connected between the structure and the metal rod of the half cell. When the protected structure is more negative than a certain voltage to the half cell then it is protected. Experience over the last 25 years has shown that steel may be protected at a potential of $-0{\cdot}85$ volts to a copper sulphate half cell.

**Engineering Techniques**

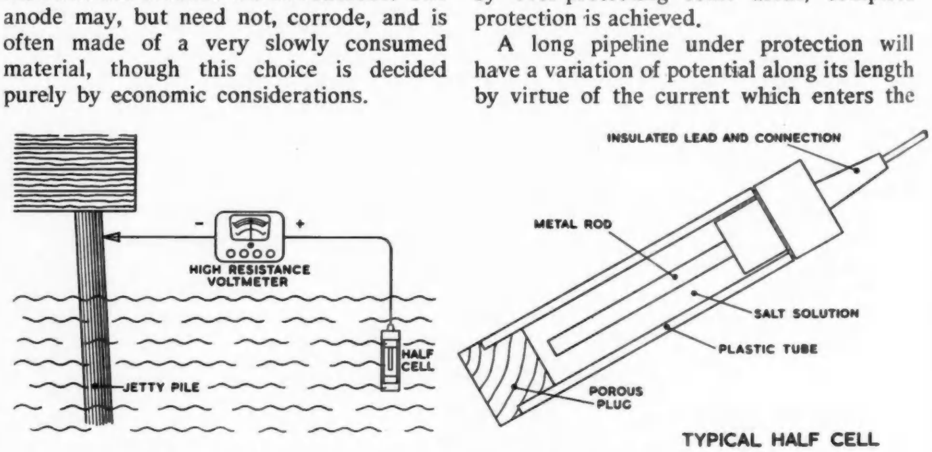
The cathodic protection current can be generated by two methods. Firstly, a large galvanic primary cell can be formed in the corroding electrolyte with the structure acting as the cathode; this is achieved by burying or immersing a mass of base metal, such as magnesium, in the electrolyte and connecting it electrically to the structure that is to be protected. The natural difference in potential between the structure metal, say steel, and the magnesium causes an electric current to flow from the magnesium, which is the anode, through the electrolyte to the steel which is the cathode. The structure is protected when this installation is engineered to provide an adequate




Equivalent electrical circuit.

current; in doing so, the anode corrodes and is called a "sacrificial anode." Three metals or alloys may be used to protect steel: zinc, aluminium and magnesium.

The second method uses conventionally generated direct current from rotating machinery or by rectification of an a.c. supply. The negative pole of this generator is connected to the structure and the positive pole to an introduced anode so that the structure becomes the cell cathode. The anode may, but need not, corrode, and is often made of a very slowly consumed material, though this choice is decided purely by economic considerations.




Method of measuring structure potential to determine the adequacy of its cathodic protection.

Where cheap energy is available and large currents are required, then the second or impressed current system will generally be preferred; while for small amounts of current, or where energy is neither readily nor cheaply available, the sacrificial anode system is usually found to be advantageous. Whilst enough current is flowing to cause the structure to display a sufficiently negative potential relative to a half cell the metal is completely free from corrosion. If impressed current is used and permanent anodes employed, then the structure is protected as long as the generating plant provides adequate current. Most permanent anodes corrode slowly and must be replaced periodically, choice of time interval and material being selected to give the most economical arrangement.

Sacrificial anodes corrode to provide the protection current and have a definite life, in terms of ampere-hours charge, which is related to their weight. The rate of consumption of the anodes is defined by Faraday's Laws though the process does not occur with 100 per cent efficiency. This may be because the metal corrodes without providing any useful current or that certain parts of the anode metal do not corrode at all. The efficiency often depends on the current density at the anode and increases at high current densities. Anode metals that have low efficiencies cannot be used to provide long life protection, say of 25 years, while those that have high efficiencies, particularly at low current densities, can.

Having decided upon the current density required for protection the engineer is faced with the problem of providing this at every point on the structure. A poor spread of protection can be caused by potential variations in either or both the structure metal and the electrolyte. The effects of these changes can be minimised by good engineering and an allowance made for them so that by over-protecting some areas, complete protection is achieved.

A long pipeline under protection will have a variation of potential along its length by virtue of the current which enters the metal remote from the cathode lead. Similarly, there will be a change in the potential of the ground under the base of an oil storage tank and this will occasion some over-protection at the edges to ensure that the bottom centre is protected. Models can often be used to analyse these problems and to determine the effects of variations in the cathodic protection design.

**Applications**

All sizes and types of buried pipes and pipelines can be protected. The corrosion of buried small service pipes can be prevented by attaching sacrificial anodes to them or to an associated body, such as a buried petrol station storage tank, to which they are connected. Long pipelines are invariably coated and wrapped with considerable care so that a few impressed current installations can give complete protection. Oil wells, off-shore pipelines and sea transport pipelines can similarly be protected as can the outside areas in contact with the ground of the steel storage tanks that these pipelines usually serve.

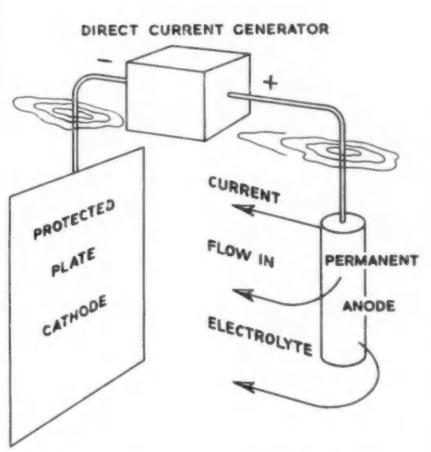
Sea water is the most corrosive bulk electrolyte met in nature. Docks, jetties, wharves, buoys, floating docks and pontoons all corrode rapidly. Those areas submerged during most of the tide can be protected cathodically and the engineering is usually simple where the sea water is undiluted.

**Small Structures**

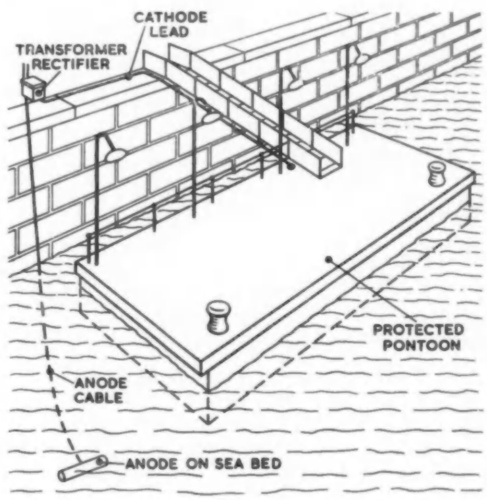
Buoys, markers, and similar small structures are usually protected with sacrificial anodes. Where they can be used zinc or aluminium anodes are most economical though the low driving voltage of some of the alloys restrict their applications. Magnesium is used where high driving voltage is required, and such applications as the protection of buoy chains, and cables require a high driving voltage to ensure a good spread of protection along the links. The protection can be engineered by direct attachment of the anode to cast-in inserts to the buoy by welding or bolting, or anodes can be suspended from the anchor chain or freely in the water when an electrical cable making a good connection between the anode and the structure must be used. Where the sea bed is suitable the anode may rest on the bed and be connected electrically to the structure. One particular class of structures that are susceptible to this method of protection are ships which are laid up for a short period when anodes may be suspended over the side to provide them with cathodic protection.

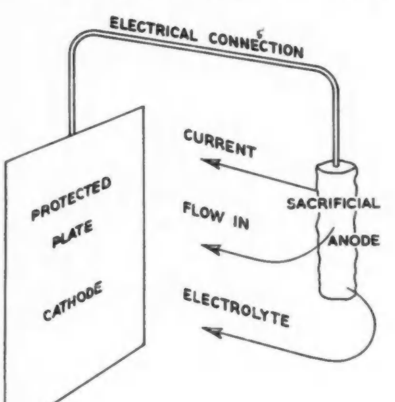
**Large Structures**

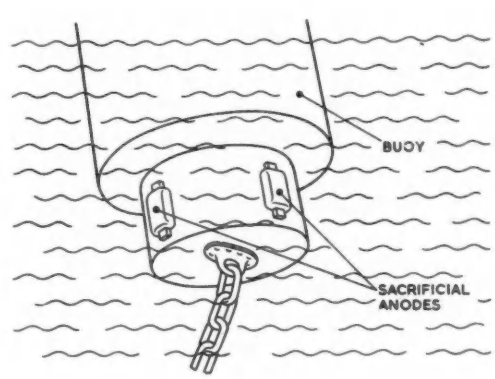
Where a large current, say in excess of 10-amps is required, then impressed current techniques are generally preferred. These are easier to engineer and control and they have a long life with the minimum maintenance, and in general where there is a.c. power available, provide the most economical method of achieving protection. The power is usually derived from the local a.c. supply via a controllable transformer rectifier, and is fed through permanent or consumable anodes into the water and hence to the protected structure. The size of the transformer rectifier generator, its capacity, housing and adjustment, will to a large extent depend upon the structure to be protected, and these structures can be sub-divided as follows:




Impressed current cathodic protection.




Sacrificial Anode Protection.

**Floating Structures**

Large floating structures, such as dry docks, floating jetties and laid-up and fitting-out ships can be protected by impressed current techniques. The anodes can be suspended from the structure or they can be mounted on neighbouring structures or where suitable laid upon the sea bed. They should be sited where they will not be damaged by ship's anchors or by dredging, and preferably in a zone where they are unlikely to be silted over. The current required by these structures is usually independent of the state of the tide, but in estuaries there may be a change of resistivity which will affect the current output of the transformer rectifier. The unit can be set so that despite fluctuations in the current output continuous and effective protection is achieved. Ships that are fitting out, particularly those that are newly launched, will be susceptible to paint damage if excessive cathodic protection is applied to them, and in these circumstances the impressed current should be carefully controlled preferably with automatic equipment.

**Wharves, Dock Gates, or Steel Piling**

The protection of this type of equipment is comparatively straight-forward. The anodes must invariably be placed in the water off the wharf, and current flowed on to the wharf face. The larger amounts of current demanded by the wharf because of its large surface area (usually 50 per cent greater than its frontal area) means that there will be considerable potential change close to the wharf in estuary waters. Care must be taken in engineering the protection to ensure that this potential gradient does not in any way affect ships which tie-up alongside. These ships should be electrically bonded to the wharf and provision made for doing this when the cathodic protection is designed. Interlocking sheet steel piles which are driven into the ground are not sufficiently electrically continuous for

them to carry heavy currents without a considerable voltage drop along the wharf. It is, however, normal practice to weld the piles together at the top where they tend to rise or move, and it is essential for cathodic protection that the piles are electrically continuous with a very low electrical resistance along their length. If this is not so, there is a poor spread of protection. On very long wharves it is customary to attach the electrical connection to the wharf at several points along its length so as to reduce the amount of current drawn from any one point on the structure.

**Piled Jetties and Wharves**

Jetties, wharves and finger piers are often built on a foundation of steel piles. These are spaced apart and it is possible to protect such structures against corrosion either by placing the anodes within the structure or by placing a single anode remote from the structure. As can be imagined, there will be a shielding effect by piles next to the anode, and this will mean that a large number of anodes will need to be placed between the piles, and it will also occasionally prohibit the use of a single anode outside the piles, as the outer piles may prevent the current flowing to the central rows.

In both cases, impressed current techniques will invariably be most economical. Platinised titanium or similar materials can be suspended, held in between the piles, or the same anode material can be used to form a massive electrode some distance from the structure to protect it. In both cases, a comparable current will be required and this is probably best derived from the a.c. mains on the jetty. With the large single anode a heavy well protected cable will need to be taken to the anode, and if this is laid on the sea bed off-shore, then the cable will need to be anchored and protected particularly where it comes ashore. This cable will need to be highly impervious to sea water and close to the anode will need to resist the products of the anode reaction; it is usual to use polythene insulation with p.v.c. sheathing on these cables.

Anodes that are mounted within the jetty structure can either be suspended freely or fixed to the structure, or under some conditions, laid on the sea bottom.

At oil loading jetties, or in hazardous locations, there would be serious disadvantages in using a single remote anode. The current flowing on to the jetty can flow into the hull of a ship causing a heavy current, of tens of amperes, to flow either through the ship's bonding cable or through hoses, gang planks, etc. While the voltage of this current is very low an inductive spark of ignition intensity would most probably occur were one of these connections broken, or even should a metallic gang plank move so as to make and break contact with some earthed steel on the quay. Very much less effect is produced from anodes distributed between the piles and this technique is much to be preferred under these conditions.

**Ships and Harbour Craft**

The small ships and harbour craft that are associated with most docks are themselves susceptible to cathodic protection. Much use is made on these vessels of anodes of zinc, aluminium, and — though now to a much smaller extent — magnesium. Impressed current techniques can be used to protect these craft, and these have many advantages in that the more rapid corrosion often found on the stern frame and propeller of tugs, can be prevented by impressed current techniques.

Cathodic protection is a rapidly growing technique for preventing corrosion of steel and other metals. It can be engineered to provide considerable savings in the maintenance of dock and harbour installations, and its future will only be limited by the imaginative uses which maintenance engineers can find for it.

The author wishes to thank the directors of Sturtevant Engineering Company Ltd. for permission to publish this paper, and to illustrate it with line drawings from their publications on cathodic protection.

# Wave Recording for Civil Engineers

## Discussion on Papers Presented at Conference

At a Conference on Wave Recording, organised jointly by the National Institute of Oceanography and the Hydraulics Research Station four Papers on the recording of marine waves for Civil Engineering purposes were presented. They were published in this Journal in the issues of September, October (2) and November.

The Papers were followed by a discussion in which opinions were expressed about various types of wave recording instruments, and their performance in practical use and there was a good deal of exchange of questions and answers. The gist of the discussion is given below in the form of comments on wave recorders in the order adopted in Mr. Draper's Paper where the instruments were described.

**Instruments to measure waves from above the water service**

Photographs and cine films taken from the shore only a few yards above the sea level have the disadvantages that the whole of the surface of the sea from the shore to the horizon subtends only a small vertical angle at the camera and that the view may often be deficient in stationary objects for fixing direction and distance.

A method of recording wave heights from the shore was described in which the vertical wave movements of a loosely-moored float are observed through an instrument on the principle of a theodolite for measuring only vertical angles. The rise and fall of the float may be recorded if the movement of the elevating screw is made to move a pen across a recording chart. The accuracy was assessed at around 9-in. in height of wave at a distance of a hundred yards or more. If necessary the float can be set in place by rocket from shore.

**Instruments to measure waves from the water surface**

What was described in the discussion as the "ideal" instrument is, in principle, the ship-borne wave recorder developed by the National Institute of Oceanography. Its prime purpose is for recording waves for research purposes and it would be expensive if applied to continuous wave recording at one point of observation, unless a light vessel or other ship happens to be stationed near the site.

Accelerometer buoys floating freely give valuable information and some of them are cheap enough to be regarded as expendable. Fixed accelerometer buoys connected by a cable or radio link to shore or ship are very satisfactory but like all floating objects they are liable to loss or damage.

Meters in which the vertical rises of the water surface are added up as they occur were regarded as very satisfactory instruments when some vertical structure is available for their fixing, particularly when they may be operated by wave power thereby needing less attention and using less chart strip because they are out of action in quiet weather, which unjustifiable generalization of the major part of the time. The time base is provided by the sequence of high tide traces but these are not always easily distinguished when the tidal range is small. Intermittent wave traces of the normal type are made by the instrument to help in analysing the waves.

The vertical wave measuring staff with stepped resistors or capacitors is simple and valuable but needs attention to avoid changes in accuracy caused by marine growths and otherwise.

It was pointed out that a floating vertical wavepole with a buoyancy chamber under

TABLE OF FREQUENCIES OF OCCURRENCE ‰ OF HEIGHT, LENGTH AND STEEPNESS OF WAVES

WAVE PERIOD (SECNDS.) 3 4 5 6 7 8 9 10

WAVE LENGTH (FEET) 100 200 300 400 500

| WAVE HEIGHT (FEET) | | | | | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0·3 | | 0·3 | 1·9 | 0·6 | 0·3 | 0·6 | | | 4 |
| | 0·3 | 0·3 | 9·4 | 38·0 | 112·5 | 40·0 | 27·1 | 6·4 | 4·8 | 239 |
| | | 0·3 | 1·8 | 14·9 | 106·7 | 75·7 | 47·2 | 11·8 | 5·8 | 264 |
| 5 | | | 1·0 | 12·2 | 57·2 | 82·3 | 48·6 | 12·3 | 6·6 | 220 |
| | 0·3 | | | 5·5 | 22·8 | 40·5 | 45·9 | 11·0 | 6·1 | 132 |
| | | | | 0·3 | 6·1 | 15·8 | 29·6 | 7·0 | 9·0 | 68 |
| 10 | | | | 0·3 | 4·0 | 6·4 | 20·0 | 5·5 | 6·7 | 43 |
| | | | | | | 2·7 | 8·2 | 3·6 | 1·3 | 16 |
| | | | | | 0·3 | 0·6 | 1·3 | 0·6 | 3·9 | 7 |
| 15 | | | | | | 0·6 | 0·3 | 1·5 | 0·3 | 3 |
| | | | | | | | | | 0·3 | 0·3 |
| TOTAL | 0·9 | 0·6 | 12·5 | 73·1 | 310·2 | 264·9 | 228·8 | 59·7 | 44·8 | |

STEEPNESS 1/10 1/20 1/30 1/40 1/50

EXAMPLE QUOTED FROM:—

"DIE MEERESWELLEN IN DER SUDLICHEN NORDSEE" BY DR H.U. ROLL DEUTSCHER WETTERDIENST SEEWETTERAMT. HAMBURG 1956

Fig. 1.

the water surface and loosely moored to a weight on the sea bed, together with a cine-camera to record the waves, can give valuable results in a short time for the immediate purposes of civil engineering works. The length of chain is adjusted so that the buoyancy chamber is held at a point below low water level. Providing the buoyancy chamber is of the right size, the pole remains almost vertical in all seas.

**Instruments to measure waves from below the water surface**

Sea bed instruments, like floating instruments, must be either self-recording or connected to the shore by some link.

The disadvantages of self-recording instruments are that no one knows whether they are working until they are retrieved, possibly weeks later, and they are sometimes difficult to attend to in bad weather. Instruments sending information to the shore generally do so by cable and in the case of piezo-electric instruments expensive cables are required while the tubes from pneumatically operated instruments are liable to damage. Pneumatically operated pressure instruments were regarded by some speakers as very simple to operate and by others as needing occasional skilled attention to maintain. In a few cases radio signals are used to transmit the information and avoid the weak link of the cable.

It was stressed that wave recorders should be simple, robust and reliable, particularly in remote parts where skilled attention is not readily available. The cost of an instrument was regarded as less important than reliability for there is little point in buying a cheap instrument that sometimes fails to record, usually during rough weather when the information would have been of most value. Some types of instruments are beautifully designed and made but are quite unsuited to areas where servicing is mainly of the hammer and chisel variety or must be done from a small boat pitching and rolling on the surface. Instruments relying on electronic equipment or recording on photographic strip were not favoured by some speakers.

Comments were made on a method of wave prediction based on a large number of visual observations by ships' officers and others, and it was reported that a check experiment was to be tried at sea shortly to find out how far different observers give consistent estimates of wave heights and period. The Conference was shown a Table (Fig. 1) showing wave heights, lengths, steepness and periods based on visual observations in the southern part of the North Sea. It was suggested that if tables of this sort could be drawn up for a large number of places around the sea coasts of the world it would be of very great value. The other view was also expressed that the correct approach to wave study was not so much to keep on measuring waves but to obtain such a fundamentally accurate understanding of their formation in different geographical and wind conditions that wave heights could be predicted even at a site for which wave records had not previously been made.

# Development of the Port of Picton, New Zealand

## Inauguration of the Marlborough Harbour Board

By F. M. BLAIR, Managing Secretary.

On the northern extremity of the South Island of New Zealand and 45 miles due west of Wellington, the capital city, lies an area deeply indented by Sounds reminiscent of those to be found in Norway.

These Sounds extend 20 to 30 miles inland and are of a fairly uniform depth of 20 fathoms. The land surrounding the Sounds is high and rugged, the peaks rising to between two and three thousand feet. The scenery is magnificent and the calm waters provide a cruising ground second to none in the world.

Captain Cook was no stranger to the protected waters, and many inlets are named after his ships and crew. At Ship Cove at the entrance to Queen Charlotte Sound, Captain Cook declared the South Island to be a British possession.

During the very earliest days of white occupation, whaling stations were established at the entrance to the Sounds, and one of these has continued to the present day, and is profitably operated by descendants of the early pioneers. The richly clad hills attracted the timber millers and gold was discovered in the streams in about 1860. The latter part of the 19th century saw many settlers carving a living from the wooded slopes and turning the rich valleys into sheep grazing areas. Today two million sheep graze the plains and hills of the Marlborough Province.

The centre of the commercial life in the Sounds was founded at Picton which lies in an arm of the Queen Charlotte Sound, 20 miles from the open sea. Picton was a flourishing town in 1850 but owing to the establishment of the capital of the Marlborough Province in Blenheim, 18 miles further south, it did not expand to any great extent during the ensuing 100 years. A regular passenger service between Wellington and Picton was established by the Union Steamship Co., of N.Z. Limited in the early part of this century and, with the construction of good roads leading southwards, Picton has become a mecca for holiday makers both from the North Island and from the Canterbury plains.

In 1912 the main trunk railway was connected to Picton thus establishing rail connection between the two extremities of the island. An overseas wharf was built by

the Railway Department and shipments of frozen mutton and lamb direct to England commenced. This state continued until the beginning of the Second World War when overseas ships were concentrated in the main ports, and the meat from the Picton Freezing Works was required to be transhipped by coastal freighter to Wellington. The cost of this was added to shipping freight rates and paid by the British Government when the meat was sold on a F.O.B. basis under bulk purchase arrangements.

In 1959 it was decided that the cost of shipping to Wellington by coastal vessel would have to be borne by the producers of the province or alternatively the port should be reopened for overseas vessels to enable direct shipments to U.K. ports to be made. The amount involved was £40,000 per annum.

As a result of this decision, a Committee of meat producers approached the Government to either require the Railway Department to bring the port up to overseas standards by the extension of the wharf from 528-ft. of straight berthage to 700-ft., and undertake a small amount of dredging, or to form a Harbour Board which would make these improvements. After some months of negotiations it was finally decided that a Harbour Board should be formed and thus on 8th August 1859 the Marlborough Harbour Board was legally constituted. As a point of interest this is the only new Harbour Board to have been constituted in New Zealand for thirty years, although many have been dissolved during that time.

The Board purchased the wharf from the Railway Department and set about its task with vigour. In terms of its Empowering Act it immediately proceeded to raise a loan of £100,000 to provide for the lengthening of the wharf by 172-ft., the purchase of mobile plant, and dredging at the wharf to a minimum depth of 35-ft. at low water. These various tasks are at present well under way, and the wharf extension will be completed during 1961. Overseas ships recommenced loading at Picton on 26th November 1959 and regular monthly sailings during the frozen lamb season have been continued. Wool, tallow, hides, salt, seeds, lucerne meal and whalemeat also form parts of the cargoes shipped overseas.

Aerial view of Picton Harbour showing work in progress on the extension to the overseas wharf. Earthworks for the Rail/Car Ferry are almost completed and piles are being driven for the 500-ft. training pier which will run along the line of test piles. The tongue of reclaimed ground will provide a launching ramp for small boats into deep water. Depth of water is about 90-ft. Tidal range is 4-ft. 6-in.

For some years, the Government had been considering the replacement of the ageing vessels in the passenger trade from Wellington to Picton by a modern roll-on roll-off car/rail ferry. The Australian National Lines had recently introduced the "Princess of Tasmania" between Melbourne and Devonport (Tasmania) and this was proving a great success in transporting tourists and cargo rapidly and efficiently between these terminii.

A similar ship to the "Princess" was planned for the Wellington to Picton run, and the Marlborough Harbour Board was allotted the task of constructing the Picton terminal. In pursuance of this, legislative authority was obtained in 1960 for the raising of £376,000 and contracts were let for the construction of a reclamation from which the Linkspan and training pier would extend parallel to the overseas wharf in Picton Harbour. As an ancillary project the Board intends to reclaim an area of 15 acres of lagoon land adjacent to the wharf. At the present time (September 1961) reclamation for the terminal is completed, the jetty structure is half completed and the linkspan contract has been let. The Terminal at Wellington which is being built by the same contractor is in a similar position.

The vessel is expected to be launched shortly from the yards of William Denny and Sons, Dumbarton, and is scheduled to come into service in May or June 1962. It is anticipated that the tonnage passing through the Port of Picton will reach 200,000 by 1963 through the advent of this service.

The ship will carry a minimum of 120 passenger cars, or alternatively 55 rail vehicles and 40 cars. She will run a daily service Monday to Saturday inclusive. Operational control will be held by the Railway Department while staffing will be provided by the Union Steamship Co., of N.Z. Ltd. A feature of the vessel which is to be named "Aramoana" will be spacious observation lounges from which the beautiful scenery of the Sounds may be viewed during the voyage through 20 miles of protected Sounds water. The trip from Wellington to Picton will take three and a half hours.

The Province and indeed the whole of the South Island of New Zealand cannot fail to benefit greatly from this modern service.

During the first two complete years of its existence the Marlborough Harbour Board has flourished and the trade of the Port has increased from 89,000 tons to 132,000 tons. The Board has fixed its Harbour Dues at parity with adjacent ports and has been able to meet all its financial obligations and still show a healthy cash balance without resort to rating the Harbour District, a distinction shared only with major old-established Boards.

Its magnificent deep water harbour and minimum overhead expenses have contributed to the success of this, the "Baby" Harbour Board of New Zealand.

### New Dredging Vessels for the Humber

The British Transport Docks are to provide four new dredging vessels for their Humber fleet which operates at the ports of Hull, Grimsby and Immingham. Heavy and regular dredging is required at all these ports to maintain the depth of water in the approach channels, entrances, and docks, where the amount of mud removed annually is about seven million tons.

The total cost of the four vessels will be over £1 million. They will be diesel-powered and will consist of a suction dredger, a triple-grab dredger and two single-grab dredgers. These will take the place of eight steam vessels. Both the suction dredger and the triple-grab dredger will be more than 200-ft. in length.

# Mechanical Operation of Thames Locks

## New Installations at Mapledurham, Cookham and Shiplake

*(Specially Contributed)*

AMONG the extensive renovation works which have been carried out in recent years on the locks operated by the Thames Conservancy, the most interesting features are the installation of electric/mechanical operating gear at Mapledurham and Cookham and the use, for the first time on the Upper Thames, of hydraulic power to operate the gates and sluices at Shiplake.

At Mapledurham, where electric/mechanical operating gear is now in use, the four lock gates are each operated by a 1 h.p. squirrel cage motor directly connected to the machinery by a "Vulcan Sinclair" fluid coupling, while the sluices are operated by means of a 1 h.p. geared motor mounted on the top rail of each gate. All the motors are run off the Southern Electricity Board's 415V three-phase supply, brought to the site by overhead conductors and run into the control room from the terminal pole by a short length of underground cable. The supply is then fed through the Electricity Board's fuses, earth leakage trip and meter to the main isolator switch on the distribution board.

The main switchboard along the rear wall of the control room consists of an angle iron frame carrying eight direct-on reversing contractors, four three-pole and four four-pole relays. Mounted on the back of the frame is a 240V single phase transformer to supply the control circuits at 50V. Two push-button control stations are provided, one for the head and one for the tail gates. Each panel carries six push buttons: "Open Gates," "Stop," "Closed Gates," "Raise Paddles," "Stop," "Lower Paddles," and there are nine indicator lights showing "Power On," and 'Gates Open," "Gates Closed," "Paddles Raised," "Paddles Down."

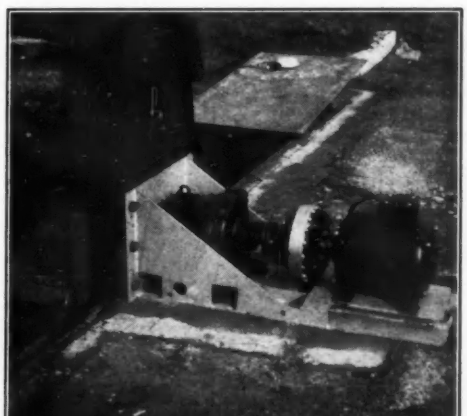
The control stations are mounted under the window, one at each end of the control room, so that the lock-keeper has a clear view of the gates he is operating. The control circuits are interlocked electrically to prevent operation of the lock in the wrong sequence and limit switches are provided which break the holding circuits when the crank handles for manual operation are engaged.

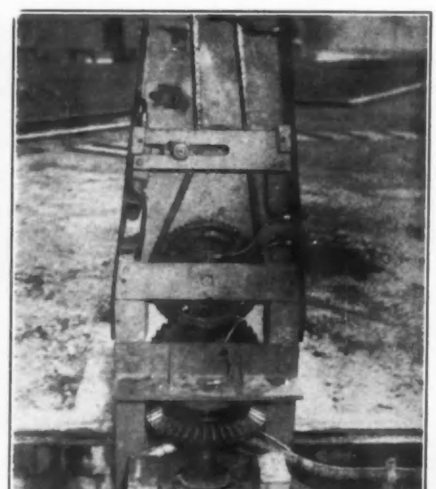
Machinery and electrical equipment at Cookham is similar to that installed at Mapledurham, but in this case there are three pairs of lock gates with a separate push-button control station for each pair. A selector switch enables the lock-keeper to operate any two pairs of gates required, the remaining control station being isolated.

The main switchboard at Cookham consists of a cabinet framed of angle iron and sheet metal. Contactors and relays are mounted on bakelite panels, the whole being enclosed by three hinged doors on the front of the cabinet. Opening any one of these doors cuts off the main supply but a key operated switch is provided for closing the circuit for testing purposes. The three-phase 415V supply is carried to the site by overhead conductors and the Southern Electricity Board's fuses, earth leakage trip and meter are situated in the lock-keeper's house. From this point a 0.0225 sq. in. 4-core mineral insulated, copper sheathed cable carries the supply across the bottom of the lock to the control office on the far side.

**Shiplake Lock**

The installation for the hydraulic operation of the lock at Shiplake was carried out by the Industrial Hydraulics Division of Lockheed Precision Products Ltd., Liverpool, and considerably speeds up traffic through the lock. It was required that the two pairs of lock gates should be capable of operation either under power by the lock keeper from local control pedestals, located near each pair of lock gates, or manually by those who wished to pass through the lock while the keeper is off duty.

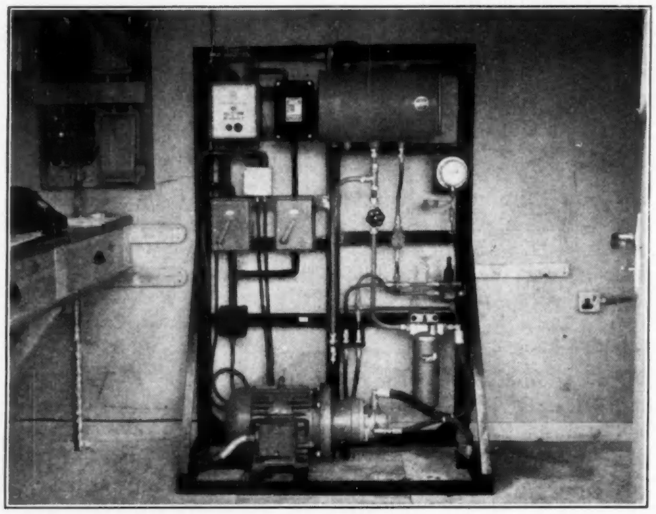




Type of lock gate machines used at Mapledurham and Cookham Locks. (Left) Rack and pinion bridle gear assembly with the limit switches. (Centre) Motor, fluid coupling and primary gear box assembly. (Right) Spur gears and chain drive for manual operation.

The hydraulic power equipment housed in the lock office meets this requirement. It supplies pressure to the pedestals which may, however, generate their own pressure supply by means of a handwheel operated transmitter. These pedestals incorporate selector units which govern the circuit to be employed to operate either the gates or sluices. Also incorporated in the pedestals are metering and reversing valves which regulate the flow and direction of the oil in the circuits, these being operated in conjunction with the selector valves when power operation is used. For manual operation, the handwheel powered pressure transmitter is used in conjunction with the selector valves, replacing the power supply from the lock office.

The equipment in the lock office consists of a 2 h.p. 400/440V three-phase electric motor and pump unit, operating at 1,400 r.p.m., which draws fluid from a 4-gallon supply tank, through a PurOlater filter, and pumps it through a pressure relief valve set at 750 p.s.i. out to the control pedestals situated at the head and tail gates of the lock respectively. Protection for the electric wiring and hose runs to the pedestals is afforded by covering them with a flagstone walk which also makes for neatness.



Lockheed hydraulic control cabinet (with front removed) installed in the lock keeper's office at Shiplake.

The control pedestals, which are identical in appearance and operation, contain the selector units for operating the sluices and lock gates, a metering and reversing valve for power operation, flow dividing and collecting valves for ensuring synchronous opening and closing of each pair of gates, restrictor valves for limiting the speed of movement in either direction, pressure relief valve set at 550 p.s.i., and non-return valves. Also included in each pedestal is a 4-cylinder ⅜-in. stroke hydraulic transmitter, operated by means of a 16-in. diameter hand wheel, this being the stand-by method of working the lock gates if the keeper is off duty.

To operate the lock gates four heavy-duty cylinders, one to each gate are fitted, having a bore of 1¾-in. and a stroke of 32-in. The sluices are operated by means of 3-in. bore cylinders, these stroking a maximum of 24-in. in the case of the head sluices and 22-in. for the tail sluices. "Hydroloc" valves are fitted near the cylinders to lock them in any desired stroke position. This prevents any possibility of involuntary movement of the gates after the motor unit has switched itself off. To protect the gates and sluices from damage when trying to open them after, say, fouling by floating trees or similar obstruction, relief valves are provided at each point.

When a boat requests passage through the lock, the keeper inserts a detachable handle into the metering and reversing valve socket of the appropriate pedestal. Having inserted the handle the keeper then selects the required movement by either raising the lever from the mid-position to set the cylinders for gate operation, or lowering the lever from the mid-position to set the cylinders for sluice operation. He then moves the metering and reversing valve handle to "Open" or "Close", as the case may be, causing an integral switch to come into operation which starts the motor and pump unit going.

Once the pump is set in motion by the initial movement of the handle, the flow thereafter is progressively metered to the cylinders, the amount of flow being directly related to the extent of the metering and reversing valve handle. It can therefore be seen that the valve itself governs both speed and direction of movement which at all times is under control of the operator.

When the lock-keeper goes off duty, he removes the detachable handle and switches off the power to the motor and pump unit. From then on, any member of the public wishing to use the lock will first select the appropriate movement, as before, but will use the hand transmitter to operate the locks and sluices, turning the handwheel in a clockwise direction to open and anti-clockwise to close. As the time for hand operation is 4½ minutes, compared with 20-25 seconds for each movement with power operation, it is easy to assess the saving that hydraulic operation can provide.

## Renovation of Shiplake Lock

Shiplake Lock dates from 1787 and was a pound lock. The present lock was built in 1874. It has an overall length from gate to gate of 133-ft. 4-in., a width between rubbing strips of 18-ft. 3-in., and an original depth over the head cill of 6-ft. 5-in., and 5-ft. 6-in., at the tail—this latter depth now being increased to 6-ft. 3-in.

The cills of the original lock, which have now been replaced, consisted of timber baulks spiked on a bed of heavy sleepers. This lock is of interest in that the quoins or corner pieces are not shaped to accommodate the heel post of the gate, but are square in section, the heel posts being hung on pintles set in front of the quoins and secured to them by iron collar straps at the top. A water seal is made between the heel post and the wall by means of a mitre board. In the renovated lock a strip of "Linatex" rubber has been incorporated in the edge of the mitre board to improve the seal. In common with many locks of early date, no hard floor was provided between the mass concrete lock walls, although timber baulks of substantial section were set in the earth floor to act as struts between the bases of the walls.

Renovation, which entailed closure of the river to traffic, was carried out between October 31, 1960, and February 6, 1961. The need for a major overhaul was brought about by the deterioration of a number of factors. The first of these was the tilting of the headgate pintles which were progressively moving out of true alignment as the timber sleepers under the cill deteriorated. This caused jamming between the pintle casting and the heelpost shoe casting. Considerable leakage was also taking place under the timber sleepers and through lift construction joints in the cill wall, thus impairing the operation of the lock. The timber cills were also worn on their surfaces, in addition to being decayed, and had been recapped several tmes to ensure a tight fit between them and the gates. Further causes of anxiety were the decayed state of the old timber baulks bracing the toe of the lock walls and the unsound nature of the lock floor.

The site preparations for lock repairs are normally governed by absence of road access to the site and with the river closed, it is usually necessary to bring all materials and equipment, including sufficient barges for transportation of broken stone, to the site before the lock is sealed off. In this instance, road access was available at a point some 100 yards from the lock, but

separated from it by a water meadow liable to recurrent flooding and by a 60-ft. wide leat which formed the water course to a mill which existed near the site in earlier times.

Preparations thus commenced with the transport by barge and erection of a 3 ton Butters luffing derrick, which commanded the body of the lock with the exception of the gate recesses. This crane was supplemented by a Priestman Wolf crane fitted with a 40 ft. boom for service at these two points, this being

Work in progress at Shiplake Lock, November 1960.

augmented when necessary by a 3½ ton Grafton steam crane mounted on one of the barges. The concrete preparation plant consisted of a 15 ton Portasilo to which cement was delivered in bulk by the C.M.C., this unit being set up in conjunction with a Parker 14/10 mixer with weighbatcher and scraper unit. The batching and stockpile yard was located above the general flood level, on a levelled dump of Thames ballast by the road side. The aggregate and sand used for the works were Kennett gravels, derived from Hall & Co.'s pit at Theale.

The type of conveyance for the concrete from the batching plant to the lock was determined by the existence of waterlogged ground and a 60-ft. wide leat, limited space on the lock side and the desirability of crossing the lock itself. Transportation was thus by means of a Road Machines Monorail system in which 10 cu. ft. skips are driven by a 7½ B.H.P. motor and hydraulic drive. The skips are set in motion at the loading point and travel unattended until stopped automatically wherever a stopping device is fitted in the rail. This was found to be particularly useful in that the rail was taken over the lock and along one side. A further section of rail was located on the other side of the lock and upon these rails was mounted a travelling bridge which traversed the lock length. A riser rail connected the main monorail system to a short length of curved rail on the bridge. Concrete was discharged from the skips, through openings in the floor of the carriage to elephants trunking for the various sections of the work.

Of particular importance in the scheme was the provision made by Henry Sykes Ltd., Southwark Street, London, S.E.1, for a reliable drainage and pumping system. The work was carried out during the wet season, when high head and tail water conditions could be expected at the main cofferdams and when the ground water level would be close to surface. Experience on work at other locks had shown that the throttle settings of normal self-priming centrifugal pumps required constant attention to reduce the amount of time lost through the flooding of the workings.

When pumping from a sump with 22 ft. vertical suction it was found that with the setting too far advanced, or with a slackening of the inflow, the sump would be emptied and the suction lost and while the priming was being regained, the water level would rapidly rise in the workings. Similar delays had been experienced when sudden inflows were encountered or when the pump speed fell for any reason. Such pumps also required to be set immediately over the lock, thus reducing the working space available.

Past experience indicated that an inflow of up to 90,000 g.p.h. might be reasonably expected, and to allow for unforseen contingencies two Sykes 8-in. Univacs were installed to deal with twice this capacity. The use of these pumps enabled a horizontal as well as vertical suction to be used, enabling the pumps to be located well clear of the working area, while of greatest importance was the fact that the water level in the sump remained constant at the level of the flange on the base of the suction pipe. The pumps were arranged to deliver to the spillway of the old mill which served as a useful collecting launder for the gravel pumped out by the Univacs. The pumps were powered by Ruston & Hornsby 4 HVR oil engines. Both pumps were used each morning for rapid dewatering. Thereafter one was sufficient to deal with seepage water. At a total head from all causes, of about 30 ft. including a vertical lift of 22 ft., the inflow was well within the pumps capacity of about 90,000 g.p.h. at this duty and worked for much of the time "on snore". Site lighting was provided by mains electricity to enable the pumps to be started up some two hours before the shift began, during which time the lock was emptied of some 210,000 gals. of water which accumulated during the night. A pump was also run for two hours after the shift had finished to enable the concrete to set.

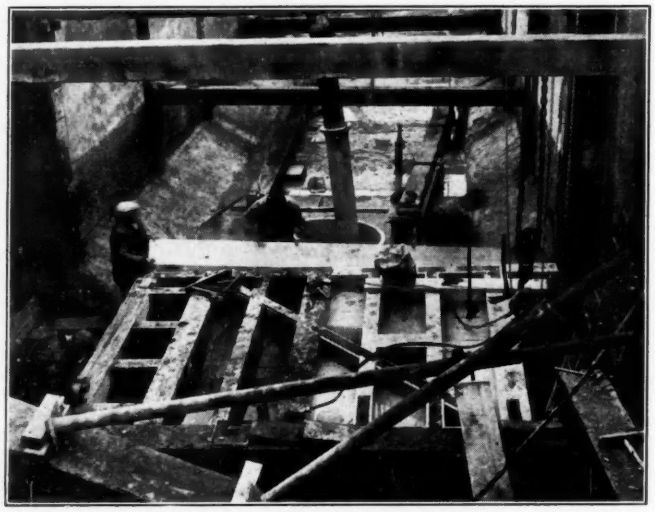
The operations started with the driving of the head and tail cofferdams. Larssen No. 2 piles, pitched by the Priestman crane and driven by a No. 5 BSP steam hammer, were used at the tail, where extra strength was required to accommodate the greater water pressure loading; number IU Larssen piles were used for the head dam. At this dam, the pitching and driving was effected by the barge-mounted Grafton steam crane. The bracing at the

Work in progress at Shiplake Lock, February 1961.

head dam consisted of 12-in. by 12-in. struts, braced off the wing walls of the dock. For the tail dam two 21-in. by 8¼-in. RSJ of 40-ft. length were used strutted from sheet piling driven into either bank.

Baulks of Douglas Fir were then wedged into position at 15-ft. centres along the length of the lock, this spacing being arranged to coincide with the existing vertical rubbing strips of the lock. These baulks were set in two tiers, the lower tier being emplaced by diver whilst the lock was still full, each baulk being temporarily weighted with a length of Larssen piling.

With the dams completed, the wall struts in place and the Univac pumps in position, the lock was pumped out, the suction line being placed in the tail recess of the lock. When the water was taken down to within a few inches of the bottom, a 5-ft. dia., 6-ft. deep sump was excavated just upstream of the tail gate



The lock gate under construction.

recess. This took place inside a box of trench sheeting, 5-ft. dia. precast concrete tube sections being used to form the sump to a depth of 4-ft. below formation level which allowed 1-ft. 6-in. below the invert of drainpipes to accommodate gravel, etc.

This box sheeting was then extended up the length of the lock in the form of a 2-ft. wide trench in order to drain the head of the lock, the trench being filled with hard core over drain. Excavation of the floor of the lock followed up the completed hard core drain in 15-ft. sections, the trench sheeting being removed and a 2-ft. thick mass concrete slab of 7.4:1 total aggregate cement ratio being emplaced to within 3-ft. of each wall. On completion of the floor, the remaining 3-ft. strip at the base of the walls was removed and any over excavation under the walls filled with concrete and underpinned 2-ft. 6-in. back, the last stage being the emplacement of a 30° batter to the walls.

The drain was thus covered over. Its function during the works was to drain both the head and tail dams, the Univac holding the water level permanently at the level of the soffit. On completion all sumps were concreted, sealing the underdrainage system.

While this work was in progress, cills and quoins were constructed at the head and tail of the lock. The new cills consisted of 31.33 lb./ft. steel channels of 12-in. by 4-in. section, set out on new 2-ft. thick slabs, the channels being bolted down to their bases by Rawl-bolts and secured to the step concrete behind by welded attachments to the channels. Repair of the lock walls consisted of cutting back the old face to a depth of some 2½-in. and then refacing with gunite to a depth of 2-in. over a B.R.C. reinforcing fabric. New tail gates, each having three sluices were fitted. These gates were fabricated in the Reading workshops and delivered by water. The original head gates, which carry four sluices to each gate, were overhauled, these gates being only 7-8 years old. The gate movement and the paddles controlling the sluices were converted to hydraulic operation.

# Legislation in the Port Industry

## The Control of Vessels in Port

By a Legal Correspondent.

To say that if a port is to function efficiently the vessels using it must be properly and efficiently controlled is, of course, to state the obvious. But having said so it is pertinent to consider the extent and limitations of the powers enjoyed, in this country at least, by harbour masters. Also what their obligations are in respect of navigation in the harbour. It is not practicable, in this article, to deal with the position of these functionaries in foreign ports though, of necessity, their powers are often similar.

In the United Kingdom the extensive powers exercised by the harbour master are largely derived from an act more than a century old, the Harbours, Docks and Piers Clauses Act 1847. In addition, further powers have been conferred by the Explosives Acts and the Petroleum Acts in respect of these dangerous materials. The exercise of all these may be regulated by the Port Authority by means of bye laws.

Generally speaking the harbour master may give directions as to the mode and time of entry and departure of vessels, their positions and moorings in port, the taking on board or discharging of cargo, passengers or ballast, the quantity of ballast on board and so on. Vessels may only enter the port with his permission. He may cause them to be dismantled and, in the case of a sailing ship, give instructions as to the furling or lowering of her sails. It is his duty to appoint the place and the manner of mooring. If a vessel anchors without permission and does not move when ordered by the harbour master her master may be fined.

Naturally the harbour master may take practical measures to enforce his directions if he finds that they are being ignored. He may arrange for the recalcitrant vessel to be worked himself; and he may put men on board a vessel for her general protection. The expenses incurred in doing these things can be recovered from the ship's master by the Port Authority. It is, of course, the duty of a master to see that a sufficient crew is kept on board to protect his ship against ordinary perils.

What is the position of the ship's master vis à vis the harbour master? He need not allow his vessel to be put in peril by the foolish or negligent directions of that official and he is justified in refusing to carry out such directions when they are clearly dangerous. If an accident does occur when the vessel is obeying the harbour master's lawful instructions those on board and the owners will not be liable unless they have been negligent.

It is, normally, an important part of the harbour master's duties to see that the port is kept clear. Unserviceable vessels and other obstructions must be moved out of the way. These include wrecks and other obstacles in the approaches to the port and any floating timber which is a hindrance to navigation. These powers arise under the 1847 Act which has now been applied by Order to aircraft. Hence "wreck" and "vessel" cover aircraft and the word "owner," in this context, means the person owning the aircraft when it was wrecked or abandoned. The harbour masters of the Royal Dockyards have similar powers to the foregoing under the Dock Yard Port Regulation Act.

If a vessel has to be moved for the repairing of harbour works or the cleansing or scouring of the harbour her master must be given written notice. If the master refuses to move her or if he cannot be traced the vessel may be moved by the harbour master at the expense of the master or owner. But the harbour master must give three days' notice of the repairs and of the necessity for the removal to the district collector or customs and put a notice up in the custom house and the harbour authority office.

Whenever a harbour master moves a vessel he must, of course, see that it is done properly. This was established by a rather old

but still valid case between the harbour board of East London and the Caledonia Landing, Shipping and Salvage Co. Ltd. and the Colonial Fisheries Company Ltd. The harbour master had, legitimately, moved two vessels, a steam tug and a coal hulk, to make a clear course in the river for craft taking part in a regatta. The day after the regatta there was an extraordinary flood. The tug with her caretaker on board was swept out to sea and never seen again. The hulk sank. The plaintiff owners claimed that the vessels had been moved from permanent and perfectly safe moorings and attached, bows downstream, to temporary moorings unfitted for any save normal weather conditions. They said that the vessels should have been returned to their permanent moorings or otherwise made safe as soon as the regatta was over. The port authority argued that the flood that carried them away was so abnormal and unprecedented that they could not be held liable.

The court found that the harbour master had acted within the scope of his duties, that the vessels had been negligently moored, that they had been moved from a much less dangerous position and not remoored despite warnings about the weather and the gradual increase in the water coming down the river. Accordingly the authority were held liable.

If a vessel has been laid by or so neglected as to be unfit to go to sea the harbour master may remove her from the port. If necessary the expense may be recovered by summary complaint before a Justice of the Peace who may issue a distress warrant against the vessel concerned.

The expense of removing vessels and obstructions often gives rise to some difficult questions involving as they often do problems of liability for collision and abandoning. Legal decisions have established that the debt may be recovered from the person who was owner when the actual removal expenses were incurred even if he was not the owner when the obstruction took place. It should be noted that ship owners who abandon a vessel that has sunk through their negligence cannot thus escape their legal liability.

It has, however, been held that where a steamer negligently sank a barge which the owner then abandoned the expenses that arose could be recovered by the port authority from the steamer's owners. This was so because the wreck had become abandoned as a result of negligence and misconduct of those in the steamer.

It may seem a self evident proposition that a port authority cannot recover if the obstruction has been caused by their own negligence. But there was, in fact, a legal dispute about this some fifteen years ago, between the Trustees of the Greenock Port and Harbour and British Oil and Cake Mills Ltd. A crane had fallen into the dock. The trustees removed it and also started an action against the company owning the crane to recover their expenses under Section 56 of the Harbours, Docks and Piers Clauses Act.

Meanwhile, however, the company themselves had commenced an action against the Trustees whose negligence they said, had caused the crane to fall. The company claimed, successfully, that the Trustees' action against them for the expenses of removing the crane should be deferred until the question of the Trustees' liability to them had been settled in their action. It was held that Sect. 56 was subject to any liability of the port authority and so the Trustees' action was deferred.

A harbour master must exercise his powers fairly and reasonably. If he does not he is liable to a fine. And if he acts negligently he may, of course, make his Authority liable.

Finally, an illustration of a port authority's liability in negligence is afforded by the action brought by the Compagnie Maritime de la Seine against the Shoreham Harbour Trustees and the South Coast Railway in respect of damage to their steamer "Bearn." This vessel had been damaged by a hump of coal, iron and engine room rubbish that had apparently been thrown overboard by the excursion steamer, "Worthing Belle" just before she moved from the berth in question to make room for the "Bearn." The port authority declared they were not liable for this as they had had no report from the local pilots who were under a duty to take soundings and make periodical inspections; in any case periodical inspections could not be expected to guard against such an eventuality since the rubbish had been thrown overboard only just before the "Bearn" moved in to the berth.

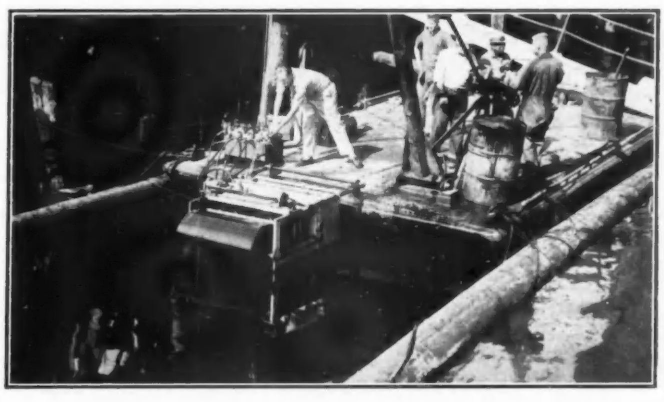
For their part the railway company declared that although the berth was theirs the responsibility was on the Authority and they were not negligent in being unaware of such a defect.

The court held both defendants liable. The railway company, as wharf owners, should either have made sure their wharf was reasonably fit for use or warned the plaintiffs that they had not done so. As for the port authority the court said uncompromisingly that they had not taken sufficient care. They could not shift their duty on to the local pilots who were not their employees and sounded only so as to navigate efficiently the vessels for which they were responsible. As regards the question of periodical inspections the court said the defendants had not done this duty properly and could not be heard to say that, even if they had done it properly, the defect would not have been detected and it would have made no difference.

## Oil Recovery Barge for Maryland

The Maryland Port Authority recently demonstrated a test model of a new type of oil recovery barge and they have now announced that a full-scale craft will be constructed in the near future for use in Baltimore harbour.

The model, incorporating a new roller principle, is expected to collect between 60-80 per cent of surface oil, compared to 1-5 per cent retrieved by existing methods. It was developed by M. Mack Earle, Naval architect, working with staff members of the Port Authority and the Baltimore City Fire Department, who will share the cost of its construction and operation.



Demonstration of test model of oil recovery barge.

The hazard of surface oil has been a considerable problem at Baltimore harbour where low tidal fluctuation causes complications. The system employed in this new device is similar to that used in the offset printing press process where rollers attract the oil while rejecting water and air. The system overcomes the problem of surface motion and can be applied to stationary recovery units, floating craft or can be buoyant in itself.

The Port Authority, in conjunction with Mr. Earle, will develop final plans and specifications for a self-propelled craft using the new principle and it is expected that this vessel will be in operation in the port in early 1962.

# Permanent International Association of Navigation Congresses

## Abstracts from the Annual Report of the British National Committee, 1960-61

At the Annual General Meeting of the British Section of the Permanent International Association of Navigation Congresses, it was reported that the British National Committee had held four meetings during the year.

**Meeting of the Permanent International Commission**

A meeting of the Permanent International Commission was held in Baltimore on September 11th, 1961, and a full report of the proceedings will be published in the Association's Bulletin in due course. In addition to the usual routine matters, the following items were discussed:

(a) **Secretary-General**

Mr. H. Vandervelden, who has been acting Secretary-General of the Association, was appointed Secretary-General.

(b) **National Oil Handling Committees**

Reports were received from the United States, Germany, Belgium and France. Great Britain submitted an Interim Report covering the aspects of the design and disposition of manifolds and hose handling equipment both on the tankers and at the berths. It was decided to set up an International Commission to study the subject and Mr. C. W. N. McGowan, Chairman of the British Committee was unanimously appointed the first Chairman. The final British Report, which would include the Interim Report, would be forwarded to the Association Headquarters in Brussels in time for the Permanent International Commission's next Annual Meeting on June 5th, 1962.

(c) **National Cargo Handling Committees**

National Committees have been set up by Belgium, Denmark, France, Germany (Federal Republic), Great Britain, Norway and the United States of America. The British Committee reported that after initial difficulties concerning the exact terms of reference, satisfactory progress has been made and an aide-memoire has been compiled on the information so far received.

The work of the various Committees was reviewed and the American Section made a suggestion that an International Committee should be set up. It was generally agreed that this development would ultimately be necessary but no immediate future steps were considered other than that the National Committees should, in the meantime, continue work on their reports.

(d) **International Commission on Waves**

A bibliographical documentation on the subject was presented and draft proposals were made for revising the organisation. These proposals are to be sent to the Secretary-General where, after agreement by the Executive, they would either be sent to National Committees or discussed at the next meeting of the Commission.

(e) **Bibliographical Documentation**

Following the Permanent International Commission meeting in 1960, an ad hoc Committee was set up to prepare a system of classification for the compilation of a bibliography of articles, etc., from periodicals which contain references to work of interest to the Association. As a result, certain countries, including the United Kingdom, were asked to co-operate in a trial for the period January to March, 1961. A selected list of British periodicals was made by the British National Committee and items on this list were allocated to various members for the recording of relevant articles. The data was forwarded to Brussels for collation. The collection of this data is to be continued.

(f) **Revision of P.I.A.N.C. Regulations**

Following a proposal by the U.S.A., which was supported by the U.K., the Executive Council was authorised to set up a Committee of representatives from three countries, plus one from the Secretariat, to examine the Regulations in the light of experience and to report at the next meeting of the Permanent International Commission in June 1962. The United Kingdom offered to co-operate in this work.

**The Baltimore Congress**

The XXth Congress held in Baltimore, U.S.A. from September 11th-19th attained the usual standard for congresses of this Association and allowing for the distance from Europe, was well attended. Some 600 delegates assembled from 39 countries and on the 11 subjects for discussion 118 papers were received.

Mr. Wilson, Chairman of the British National Committee, was invited by the Chief British Delegate, Sir James Dunnett, Permanent Secretary of the Ministry of Transport to act in his place as he was unable to attend the Congress.

The American Association had been honoured by the patronage of the President of the United States who was unfortunately unable to be present at the opening ceremony which was carried out by the Secretary of State, Mr. Dean Rusk. Many of the features in the American programme followed the pattern of the Congress held in London in 1957. The Technical Sessions of both Sections were held simultaneously. The meetings of Section I (Inland Navigation) were held in the Lord Baltimore Hotel and those of Section II (Ocean Navigation) in the Emerson Hotel. These arrangements proved very satisfactory as both hotels were air conditioned and delegates were able to choose accommodation in either hotel according to their choice and so avoid unnecessary travelling.

The Meetings on the Inland Navigation papers were good and for the Ocean Navigation Section several of the subjects chosen prompted an outstanding discussion. This was particularly so in the case of oil handling. The British contribution to the discussions on siltation, nuclear powered ships, cargo handling and salvage were creditable and concise.

During the first week of the Congress, the delegates visited the U.S. Navy Academy at Annapolis. They were also taken on a whole day tour of the City of Washington, D.C., and on a tour of inspection of the Chesapeake and Delaware Canal. In addition some delegates were shown over the Port of Baltimore. At these functions, hospitality was provided by the U.S. Navy, the U.S. Army and the Chesapeake Canal and the Baltimore Port Authorities respectively.

Following the traditional procedure, the British Delegation gave, on September 15th, a small evening reception for the heads of delegations of other countries and a valuable cementing of friendships and exchange of opinions took place.

The social activities also included a Reception given by the Governments of the U.S.A., and of the State of Maryland; a concert by the United States Navy Band; a Reception at Goucher College in the name of the President of the Congress, the Hon. John Marshall Butler, Senior Senator, State of Maryland; and a Banquet, followed by a Dance, at the Maryland Jockey Club. The Reception at Goucher College was followed by an open air performance by the Baltimore Chamber Orchestra. A very full programme of local tours and activities for the ladies was provided. The post-Congress tours were as follows: (1) The Great Lakes and St. Lawrence River; (2) Ohio River—Tennessee Valley; (3) Lower Mississippi Valley; (4) New York and vicinity.

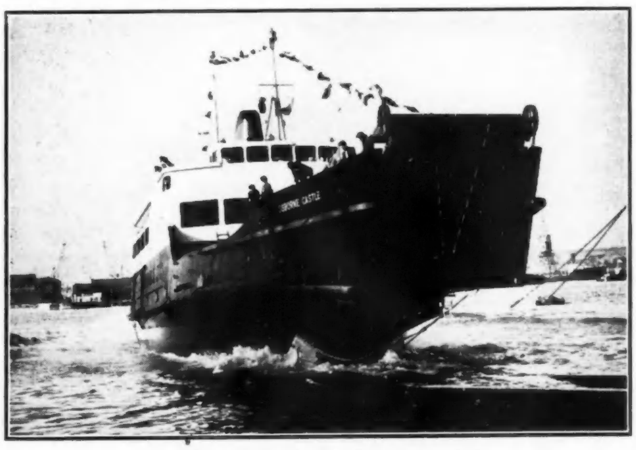
# Manufacturers' Announcements

## Pumps Speed Bulk Cargo Handling

Handling bulky cargoes of sulphur and other chemicals has always been a costly and time-wasting operation. Recently, however, loading and unloading operations in the U.S.A. have been greatly speeded up by the introduction of specially designed pumps capable of handling sulphur in its molten state heated to a temperature of 275°F. The liquid chemical is pumped directly from heated shore tanks into the cargo vessel in a fraction of the time normally required to handle a solid shipment.

Eight vertical turbine pumps, specially designed by engineers of Fairbanks, Morse & Co., industrial subsidiary of Fairbanks Whitney Corporation of New York, lift the hot cargo from shipboard tanks and transfer the liquid to storage facilities on shore. Each of the 10-in. four-stage pumps being used has a rating of 650 gallons per minute against a 140-ft. total dynamic head. The bowl assembly, disconnect box, discharge column and discharge head are completely steam-jacketed to maintain the sulphur at its proper temperature. In other respects construction of the pumps is standard cast iron, carbon steel, with stainless steel bolting. The bearings are soft cast iron, lubricated by the liquid sulphur.

It is believed that this method of handling sulphur cargoes could well be applied to other chemicals.



The launch of the "Osborne Castle."

## New Passenger/Vehicle Ferry for Isle of Wight

A new twin-screw passenger and vehicle ferry for the Southampton, Isle of Wight & South of England Royal Mail Steam Packet Co. Ltd. (Red Funnel Steamers), was launched in November from the Woolston Works of John I. Thornycroft & Co., and will be delivered to the Owners in April 1962.

Named the "Osborne Castle", the ferry has a length overall (including ramp and fender) of 191-ft. 2-in.; length on waterline of 180-ft.; a breadth moulded of 40-ft.; a depth moulded to main deck of 10-ft. 7-in.; and a draft amidships of 7-ft. With a gross tonnage of 730-tons and a service speed of 14-knots, this latest addition to the Red Funnel Fleet has been developed from the highly successful "Carisbrooke Castle" which entered service in 1959, although a number of modifications are being incorporated to improve and enlarge the passenger saloon and open deck accommodation. Some 45 vehicles can be carried on the main deck with unrestricted height at the fore end for lorries up to 20 tons in weight each. Vehicle loading is effected by means of an articulated ramp placed at the extreme fore end of the ship. Side loading is also catered for: shipside sliding doors give access to the sheltered car deck, whilst hinged bulwark doors forward provide access to the larger vehicles.

If used for passenger service only, 1,200 passengers can be carried. There is a large observation lounge on the promenade deck, leading through to a saloon and bar. This lounge, which extends the full width of the ship, provides a buffet service and large windows have been fitted to give passengers an unimpaired view. Deck seats are arranged on the promenade and boat decks and seating on the promenade deck is protected from the weather by glass windows fitted at the side and after openings.

Solid rubber side fenders in steel housing are fitted over the entire length of the vessel. Two 16-ft. lifeboats mounted in high-level davits are fitted on the boat deck.

The main propelling machinery, supplied by Crossley Brothers, Ltd., Openshaw, Manchester, consists of two vertical 2-stroke cycle direct reversing marine diesel engines, each with a continuous rating of 900-b.h.p. and speed of 450-r.p.m.

## Dredgers for the U.K. and New Zealand

The bucket dredger "W. H. Orbell" built by Simons-Lobnitz Ltd. for the Timaru Harbour Board was launched recently at their Clyde Yard.

Costing £½ million the vessel, a twin screw diesel electric bow well bucket dredge 220-ft. x 40-ft. x 17-ft. will, when completed, be used to maintain and improve navigable access to the port. More than £3½ million has been allocated for the long term development of Timaru, which is one of New Zealand's busiest export ports and the new dredge is part of that scheme.

It is understood that the "W.H. Orbell" will be the first diesel electric vessel of its type to be employed in New Zealand. She will be capable of dredging up to 1,000 tons/hour and has a hopper capacity of 750 cu. yd. (equivalent deadweight 1,000 tons), loaded speed is 9½ knots. Consideration has been given in the design for the need to dredge alongside quay walls, and dredging can be carried out to a depth of 42-ft. Spoil will be discharged through the hopper doors.

Consultants for the Timaru Harbour Board were Sir Bruce White, Wolfe Barry and Partners, London.

Early in November the Company launched the twin screw, twin side trailing suction hopper dredge "Bleasdale" which they are constructing for the British Transport Commission at a cost of approximately £500,000. When completed, this dredge will be used for maintenance dredging in the approach channel to Fleetwood harbour.

With a length b.p. of 180-ft., a breadth moulded of 38-ft. 6-in. and a depth of 17-ft. 3-in., the design of the vessel includes a bow propeller for easy manœuvring in confined areas and bridge control of the main engines, pumping motors and suction pipe winches which give greatly improved operational efficiency. The dredging pumps are each designed for an output of 650 cu. yd. of solids per hour, when working in a free getting material and the hopper capacity is 850 cu. yd. Dredging depth is 40-ft. below waterline. This vessel reflects the up-to-date requirements of the British Transport Commission and will be one of the best equipped of its type in the world.

Simons-Lobnitz Ltd. have also announced that the Yard has secured an order for a twin screw trailing suction hopper dredge, costing more than £400,000, which will be built for Blyth Harbour Commission and will eventually replace a 48 year old bucket dredge. One of the interesting features of this vessel will be a bow propeller which will allow easier manœuvring in confined areas.

## Fork Lift Trucks for Holland

The Materials Handling Division of the Yale and Towne Manufacturing Co., Wednesfield, announce that they will be despatching four Worksaver fork lift pallet trucks to Holland in December. This will bring the total number of trucks they have exported to the Netherlands to over 150.



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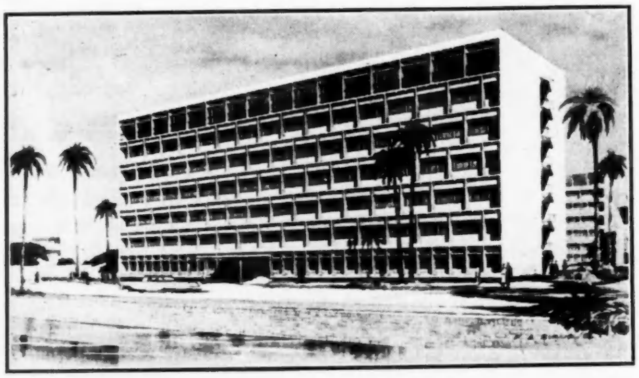
## *Manufacturers' Announcements—continued*

### New Headquarters for Nigerian Ports Authority

A modern seven-story headquarters block is to be built in Lagos for the Nigerian Ports Authority at a cost of £431,000. Due for completion in March, 1963, the T-shaped building will be fully air-conditioned and will provide some 98,000 sq. ft. of floor space, which will be divided by demountable partitioning. It will be framed in reinforced concrete and clad with hollow block infill panels and mosaic tiles. The foundations consist of a concrete raft resting on vibrocompacted sand. Floors will be of solid reinforced concrete and the building will have a highly insulated flat roof. Concrete sun-breakers between windows on the main elevations will serve a decorative as well as a useful purpose. The main glass doors and a screen in the entrance hall will be etched with a local design.

Designed by London architects, W. H. Watkins Gray & Partners, the Headquarters is to be constructed by Dys Trocca Valsesia & Co. Ltd.—a Nigerian company jointly formed by Howard Farrow Ltd., Holland & Hannen, Cubitts Ltd., and Impresa Giachetti of Turin.



Artist's impression of the new office block at Lagos.

### New Reach Truck

One major feature peculiar to the R25A Reach Truck manufactured by Hyster-Ransomes Ltd., Ipswich, is its scissor-action reach drive. A central ram actuates a pantograph which controls the 30-in. advance and retraction of the forks. The solid phosphur bronze slide blocks, which ensure permanent precision alignment of reach actuation, are readily replaceable.

Steering and drive mechanisms form one integral unit. The mast can be unshipped as an integral unit without interfering with reach or drive mechanism.

The R25A is said to be the only reach truck which provides seating for the operator who has full view both of unladen forks and of his load. Being seated, he has one hand free at all times for control of hydraulic motion.

Longitudinal stability, too, is high. With the standard 40-in. by 40-in. pallet, the bulk of the load, and the centre of gravity, are within the wheelbase. The load frame is laterally articulated to ensure that all wheels are always in load bearing contact with the ground. The truck also has greater lateral stability because of its wider track.

There is a 12-ft. lift on the standard R25A, and load rating is 2,500-lbs. at 20-in. load centre. Other heights of lift are available up to 16-ft. Fork lengths are provided to clients' requirements.